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ON THE MODIFICATIONS OF TENSILE STRENGTH AND DUCTILITY WHICH IRON AND STEEL UNDERGO WHEN HEATED TO BETWEEN CERTAIN TEMPERATURES.

[Translation by Chief Engineer Isherwood, United States Navy, of the paper on that subject read by Engineer-in-Chief E. Cornut of the North of France Association, before the 7th Congress of the Engineers-in-Chief of the Associations of Proprietors of Steam Boilers, held at Bordeaux, France, on the 10th, 11th and 12th September, 1882.]

[NOTE BY TRANSLATOR.—The influence of temperature on the ductility, elasticity, and cohesive strength of wrought-iron and of steel, though of great importance in the industrial arts, has received so little attention, owing doubtless to the difficulty and cost of the investigation, that any new experimental facts on the subject have exceptional value, particularly as plate steel in the various modifications of iron which bear that name, is coming into general use for boilers, and for the hulls of vessels, I have therefore translated the following paper read by Mr. Cornut, the distinguished Engineer-in-Chief of "The North of France Association," before the 7th Congress of the Engineers-in-Chief of "The Associations of the Proprietors of Steam Boilers," held at Bordeaux, France, on the 10th, 11th and 12th of September, 1882, which contains some valuable facts and inferences concerning this subject.

In the paper referred to, is given the true explanation of the apparently abnormal result that iron and steel increase in cohesive strength by increase of temperature up to about 550 degrees Fahrenheit, instead of diminishing, as do all other substances. The rupturing strain, it is important to observe, being referred to the original cross section of the specimen tested and not to the cross section at the instant of fracture. That such is the effect has long been known, but not the cause producing it, namely, the

great loss of ductility experienced by iron and steel when heated between certain temperatures, whereby the section of fracture of a bar of given dimensions is larger at these temperatures than at lower ones. Hence, the imaginary increase of strength due to the increase of temperature is not a physical fact but an erroneous inference resulting from an unwarranted implied assumption that the sections of fracture at different temperatures have the same proportion to the original section. As the metal loses in ductility it necessarily gains in brittleness, so that increase of the latter is proof of decrease of the former.

Had the section of fracture been measured in the few experiments on the cohesive strength of heated iron and steel which have been made, and had the rupturing force been referred to it and not to the section before the strain was applied, and had the heated metal been tested at the same time for brittleness by bending it, the cause of the *apparent* increase of strength due to increase of temperature would have been revealed, and it would have been found that iron and steel instead of being exceptions to the general law of decreased strength with increased temperature, obeyed that law.

Very important, too, in engineering, is a knowledge of the facts that the increase of temperature referred to, increases the brittleness of iron and steel, and of steel more than of iron, as it accounts for many fractures, impossible to otherwise explain, of marine engine shafts. Perhaps most of these fractures—particularly of crankshafts—are due to the overheating of the journals, which is sometimes great enough to fuse the brass of their bearings. It is well known that crankshafts, both iron and steel, the journals of which are liable to become highly heated as the pressure under which they work is often very great per square inch of surface, fracture much more frequently than their corresponding line shafts, although the latter are generally of less diameter. Steel shafts are much more subject to these accidents than iron ones, and at high temperatures the brittleness of steel due to temperature is greater than that of iron. For this reason, externally fired cylindrical boilers constructed with steel shells would, when overheated, be more liable to rupture than if constructed with iron shells.

In this connection I may remark that the high tensile strength shown by small specimens of the plate steel now coming into use for boilers and for the hulls of vessels, cannot be accepted for the plates from which they were cut as a whole. Owing to the mode of manufacture and the nature of the material, the metal of these plates is under permanent violent abnormal internal strains, and the larger the plates, the greater are these latent dangerous strains, but when a small piece is cut from them, it is relieved from these strains and being then tested shows a tensile strength much exceeding what belongs to the plate as a whole.

The existence of these abnormal strains is proven by the sometimes spontaneous fracture of the plates while lying in store, or when roughly handled or when slightly struck. They can be lessened in measure by annealing the plates, but annealing effects a very serious reduction in their strength. Plate iron is free from these strains, and though greatly less homogeneous in structure than the steel in question, is more uniform and reliable in its qualities of tensile strength, of ductility at all temperatures, and of resistance to corrosion.

In this connection the reader's attention is particularly called to the illustration accompanying Mr. Walrand's very acute experiments described by Mr. Cornut.

It is hoped that the Navy Department, which is the great user of steel for boilers and for hulls of vessels in the United States, will have extensive experiments made by means of the large testing machine at Watertown, Massachusetts, on the tensile strength of entire plates of large dimensions o steel and of the best quality of American flange plate iron. Experiments on small specimens give but unreliable information as to the qualities of the material in large masses.]

TRANSLATION OF ENGINEER-IN-CHIEF E. CORNUT'S PAPER.

A number of experimenters are now engaged in investigating the changes which occur in the physical properties, in the resistance to extension, and in the limit of elasticity and ductility of iron and steel under the influence of temperature.

I do not intend to discuss the subject, but only to call attention to a certain *hot short* (*Etat Rouverain*) condition of iron and steel corresponding to a temperature which has been approximately ascertained within moderate limits.

Mr. Charles Walrand, the engineer of the steel and iron works of the Northeast Company at Valenciennes, has published on this subject in the "Industrial Annals," of June 11, 1822, a very interesting article of which I will give you a rapid summary.

Mr. Walrand says, that Mr. Valton, on his return from a visit to Russia, showed a fact which he had observed in the steel works of Prince Demidoff. He bent several times to a right angle a round steel bar previously highly heated; and remarked that when the temperature on lowering, arrived at the iris blue color, the metal became brittle. He concluded, "*That when steel is heated to a temperature between 473 degrees Fahrenheit and 662 degrees, the mettle was more brittle between those limits than at a much lower or at a much higher temperature.*"

Mr. Walrand then undertook various experiments on iron and steel of different qualities. He forged two bars of 1 centimetre (0·393708 of an inch square) of each quality of metal tested. One of these test pieces was bent cold; the other was bent hot when it reached the iris blue color, which was ascertained by a touch of the file. The following figures represent the results of these practical trials.

Mr. Walrand asserts that, "We have found in all our experiments a greater brittleness in the heated metal than in the cold metal. This brittleness appears to be accompanied by an increase in the tensile

strength of the steel and by a decrease in its ductility. We have made experiments on the tensile strength of round bars, 1·6 centimetre (0·6299328 inch) in diameter, and 1 decimetre (3·93708 inches) long between the clamps."

The following table* contains the results of these trials:

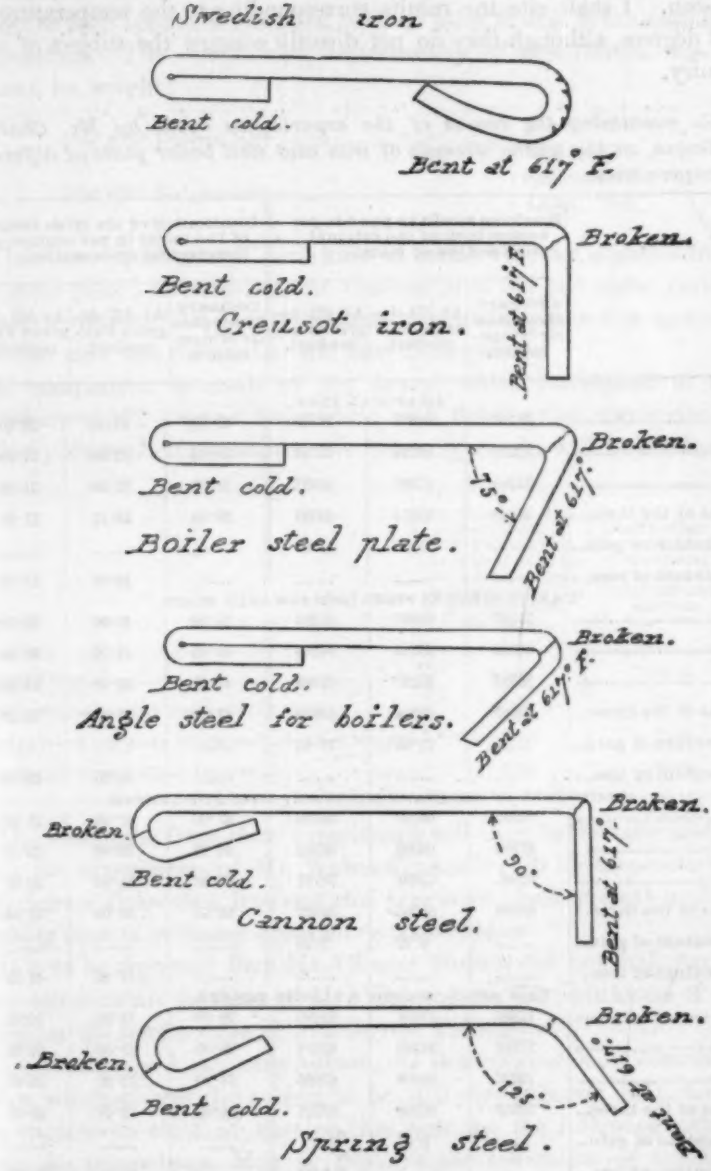
Metal tried.	Temperature Ordinary atmospheric.		Temperature 617 degrees Fahrenheit.		Remarks.
	Breaking strain in pounds per square inch of cross section.	Increase of length in inches.	Breaking strain in pounds per square inch of cross section.	Increase of length in inches.	
Swedish iron.....	50918	1·2008	67274	0·7480	Bright fracture blue color.
Creusot iron.....	52198	1·2008	68554	0·6496	Ditto.
Boiler steel plate....	60162	1·2638	77290	0.7480	Ditto.
Angle steel for boilers.....	73674	1·0866	93728	0·5906	Fracture, chisel blue.
Cannon steel.....	88808	0·8780	109956	0·4724	Ditto.
Spring steel.....	103542	0·7284	122743	0·3937	Ditto.

In the following table are the increase in tensile strength, and the diminution of the ductility, or lengthening of the metals, under the strains, due to the temperature of 617 degrees Fahrenheit, expressed in per centum of the values obtained at the ordinary atmospheric temperatures.

Metal.	Increase of tensile strength at 617° Fahrenheit over that at ordinary atmospheric temperatures in per centum of the latter.	Less increase of length at 617° Fahrenheit than at ordinary atmospheric temperatures in per centum of the latter.
Swedish iron.....	32·12	37·70
Creusot iron.....	31·33	45·90
Boiler iron.....	28·37	40·81
Angle iron.....	27·22	45·65
Cannon steel.....	20·71	50·68
Spring steel.....	18·54	45·94

In 1878 there was published in the "Annales des Mines," a summary of the remarkable experiments on the tensile strength of iron and steel

* See accompanying illustration.


Swedish iron
Bent cold.
Bent at 617° F.
Broken.
Bent cold.
Bent at 617° F.
Creusot iron.
Broken.
Bent cold.
75°
Bent at 617°
Boiler steel plate.
Broken.
Bent cold.
Bent at 617° F.
Angle steel for boilers.
Broken.
Broken.
Bent cold.
90°
Bent at 617°
Cannon steel.
Broken.
Broken.
Bent cold.
125°
Bent at 617°
Spring steel.

boiler plate at ordinary atmospheric temperatures, and at the temperatures of 572 and of 932 degrees Fahrenheit, made by Mr. Charles Huston. I shall cite the results corresponding to the temperature of 932 degrees, although they do not directly concern the subject of our inquiry.

Table containing the results of the experiments made by Mr. Charles Huston, on the tensile strength of iron and steel boiler plate at different temperatures.

	Breaking strain in pounds per square inch of the original cross section of metal.			Diminution of the cross section of the metal in per centum of the original cross section.		
	Ordinary atmospheric temperature.	At 572 degrees Fahrenheit.	At 932 degrees Fahrenheit.	Ordinary atmospheric temperature.	At 572 degrees Fahrenheit.	At 932 degrees Fahrenheit.
CHARCOAL IRON.						
No. 1	56498	60933	70118	28·00	23·50	22·00
No. 2	52297	59295	62794	26·00	22·50	21·00
No. 3	57289	62903	63092	24·00	23·50	21·00
Means of the three	55360	63074	65335	26·00	23·17	21·23
Per centum of gain	.....	13·95	18·03	.....	.....	.....
Per centum of loss	.....	.....	.....	.....	10·88	17·69
MARTIN-SIEMENS STEEL (REMARKABLY MILD).						
No. 1	51387	60091	61684	50·00	40·00	32·00
No. 2	55782	60335	64230	50·00	41·00	36·00
No. 3	56593	65107	67080	41·00	32·00	32·50
Means of the three	54587	66074	64334	47·00	37·66	33·50
Per centum of gain	.....	21·05	17·85	.....	.....	.....
Per centum of loss	.....	.....	.....	.....	19·85	28·72
INGOT STEEL OF ORDINARY MILDNESS; DOES NOT TEMPER.						
No. 1	61585	66790	65396	37·00	37·00	21·00
No. 2	67985	68582	69592	35·00	29·00	22·00
No. 3	62395	72394	70787	37·00	24·00	22·00
Means of the three	63988	69255	68592	36·33	30·00	21·66
Per centum of gain	.....	8·22	7·20	.....	.....	.....
Per centum of loss	.....	.....	.....	.....	17·42	41·29
CAST STEEL TAKING A SLIGHT TEMPER.						
No. 1	77884	79491	81606	28·00	13·25	16·25
No. 2	77784	87797	81904	28·00	23·00	22·00
No. 3	79892	80099	67985	24·00	12·00	22·00
Means of the three	78353	82762	77225	26·66	16·08	20·08
Per centum of gain	.....	5·63	.....	.....	.....	.....
Per centum of loss	.....	.....	1·43	.....	39·59	24·64

Mr. Huston heated the specimens by means of a blow-pipe in order to obtain a constant temperature during the experiments; a hole drilled in each specimen was filled with an alloy fusible at the required temperature. The composition, centessimally, of these alloys was as follows, by weight:

For 572° Fahrenheit..... { Zinc, 32·3. Lead, 67·7.

For 932° Fahrenheit..... { Silver, 24·5. Lead, 75·5

The three specimens of each kind of metal were cut adjacent from the same plate; nevertheless, the charcoal iron did not show perfect homogenousness. The Martin-Siemens steel was the most homogenous. The cast steel was the hardest and least homogenous.

If comparison be made of the figures which correspond to the temperature 572 degrees Fahrenheit, with those which correspond to ordinary atmospheric pressures, the following results will be obtained:

	Increase of tensile strength at 572° Fahrenheit over that at ordinary atmospheric temperatures in per centum of the latter.	Diminution of the cross section of the metal in per centum of the original cross section.
Charcoal iron	13·95	10·88
Martin-Siemens steel (remarkably mild)	21·05	19·85
Ingot steel of ordinary mildness; does not temper	8·22	17·42
Cast steel taking a slight temper	5·63	39·59

The conclusion from these experiments will then be the same as that from the experiments of Mr. Walrand, namely: *At the temperature of 572 degrees Fahrenheit, iron and steel have more tensile strength and less ductility than at ordinary atmospheric temperatures.*

It is to be regretted that Mr. Charles Huston did not make analogous experiments to those of Mr. Walrand on the brittleness of the metals at the temperature of 572 degrees Fahrenheit.

Unfortunately I can only submit, in this connection, a communication which proves the subject to be still very obscure. Mr. Kraft, the engineer-in-chief of Seraing, has sent me the following extract from the proceedings, May 6, 1881, of the association of engineers graduated from the school of Liège:

Mr. Greiner presented the results of some experiments which he had made for the purpose of ascertaining the influence of temperature on the tensile strength of steel. He operated on round bars 7·87416 inches long, and 0·590562 inch diameter. In submitting two identical bars to traction, one at the ordinary atmospheric temperatures, the other at about the temperature of 572 degrees Fahrenheit, which is that of smoking wood or boiling oil, Mr. Greiner found notable differences in the tensile strength, and especially in the lengthening of the bars at rupture.

The experiments were made on steel of the four great classes of the Seraing scale, which are characterized by the following properties:

	Per centum of carbon.	Breaking strain in pounds per square inch of cross section of metal.	Increase of length in per centum of the original length.
1st Class (extra mild)	0·05 to 0·20	56891 to 71114	27 to 30
2d Class (mild)	0·20 to 0·35	71114 to 85337	20 to 15
3d Class (hard)	0·35 to 0·50	85337 to 99560	15 to 10
4th Class (very hard)	0·50 to 0·65	99560 to 113783	10 to 5

All commercial steel belongs to one of these four classes.

The experimental results are given in the following table:

	At ordinary atmospheric temperatures.		At the temperature of 572 degrees Fahrenheit (annealing blue).	
	Breaking strain in pounds per sq. in. of cross section of metal.	Increase of length in per centum of the original length.	Breaking strain in pounds per sq. in. of cross section of metal.	Increase of length in per centum of the original length.
1st Class	62580	26	49780	11·4
2d Class	81070	19	69692	10·0
3d Class	89604	20	72530	8·7
4th Class	105249	16	85337	7·25

As a general result there is a diminution of 20 per centum in the tensile strength, accompanied by a diminution of 50 per centum in the lengthening or stretching.

Mr. Greiner is in accord with Messrs. Walrand and Charles Huston that steel at the temperature of 572 degrees Fahrenheit is a great deal less ductile, and consequently more brittle, than at ordinary atmospheric temperatures; but he is not in accord with them on the results of the heating of the metal in regard to its effect upon the tensile strength. Mr. Greiner found the tensile strength to diminish, Messrs. Walrand and Charles Huston found it to increase by heating.

If, as in the previous cases, there be made a table of the differences, the following will result:

	Diminution of tensile strength at 572 degrees Fahrenheit below that at ordinary atmospheric temperatures in per centum of the latter.	Less increase of length at 572 degrees Fahrenheit than at ordinary atmospheric temperatures in per centum of the latter.
1st Class	20·45	56·15
2d Class..	14·03	47·87
3d Class.....	19·05	56·50
4th Class.....	18·92	54·69

On this subject I have consulted my friend Mr. Barba, principal engineer at Creusot, whose competence in these matters is well known. He regards as absolutely certain the fact that *towards 572 degrees to 662 degrees Fahrenheit, iron and steel pass into a peculiar hot short state* (*Etat Rouverain*). He adds:

> At the same time as regards experiments on the tensile strength, the resistance *appears* to increase, the limit of elasticity *appears* to diminish, as well as the amount of stretching or lengthening at the moment of rupture. I say *appears*, because our experiments on this subject are not numerous enough to make these results certain.

This hot short state (*Etat Rouverain*) appears then to me impossible of discussion by existing data; all investigators admitting that new experiments are necessary to determine the exact conditions of its formation according to the nature of the metal, and of its influence on the tensile strength and the limit of elasticity. But the knowledge that there is such a state, furnishes a satisfactory explanation of some accidents which happen to metals. Thus Messrs. Krafft, Barba and Walrand attribute to this *Etat Rouverain* the fracture of the friction bands of brakes in consequence of too intense action.

As regards the construction of steam boilers, this *Etat Rouverain* enables us to assign a cause for the fracture of their curved ends and of their flanges in the case of excellent metal worked hot. In fact, it is enough for the boiler maker to continue heedlessly turning a flange after the metal has fallen to the iris blue temperature, to produce a slight crack in the turn; this crack will increase under the ordinary contraction and dilation of a boiler in use, and become dangerous in time if not discovered by minute inspection.

To this *Etat Rouverain*, I believe, should also be attributed the many breakages produced in the plate of a boiler when it is thickened by upsetting the metal with a hammer after being slightly heated in position.

Further, I know this particular state of brittleness in iron and steel when approaching the temperature of 572 degrees Fahrenheit, to be so well understood in our great iron-working establishments, that their blacksmiths are directed not to continue forging after the iris blue color appears.

CORES FOR MELTED STEEL.—M. Gladsden has devised certain improvements in ventilating cores, which are designed to facilitate the escape of gases during the flow of melted metals, in order to avoid blow-holes. In the centre of the mould there is attached, by a bolt upon the metal plate which supports the mould, a perforated iron tube placed vertically. Around this tube, when there are to be large castings, is rolled a cord of hay, straw, or other like material. This vegetable cord is coated with silex, pure or nearly pure, with the addition of some mild liquid, such as glue, water, or sour beer. If the pieces are of more moderate dimensions the coating of silex is applied directly to the metallic core. Refractory cores and perforated metallic cores have already been used independently, but Gladsden claims priority for the combination of the two methods. The entrance of the metal may be made either from above or still better from below; the slag will then be lifted to the upper level of the core, while the gases escape by the centre, through the silicious coating.—*Chron. Industr.*, April 13, 1884. C.

CLEANSING OF LIEBIG'S STATUE.—This marble statue, which was inaugurated at Munich in the month of August, 1883, was sometime afterwards covered with brown spots, which were absolutely ineffaceable by the ordinary methods. The members of the commission, which was appointed to study the nature of the spots and try to effect their removal, have just published an account of their labors in the Bulletin of the Berlin Chemical Society. The analysis of the spotted portions of the statue showed the presence of silver and of manganese; hence it was concluded that the spots had been produced by a mixture of permanganate of potash and nitrate of silver. A series of experiments showed that the spots could be dissolved by transforming the silver and the manganese into soluble sulphurets. In order to effect the transformation, the spots were covered at many different times with kaolin, in a paste soaked with sulf-hydrate of ammonia. Washing with water then made the excess of alkaline sulphuret disappear. It was then only necessary to dissolve the sulphurets in cyanide of potassium with which a layer of kaolin was soaked. The operation perfectly succeeded, to the great satisfaction of the savans of all countries.—*Genie Civil; Chron. Industr.*, April 27, 1884. C.

MODERN RAILROAD FACILITIES.*

By Wm. Barnet Le Van.

HISTORY.

Eighty years ago, Oliver Evans, who deserves at this day all the honor that can be conferred on man as one of Philadelphia's noblest sons, made the first application in the streets of this city of steam to a carriage in America, and, in fact, the first locomotive engine. This experiment was more successful than any that had preceded it.

About this time, Evans publicly stated that "The time will come when people would travel in stages, moved by steam engines, from city to city, almost as fast as birds fly—fifteen or twenty miles an hour—passing through the air with such velocity, changing the scene in such rapid succession, and with the most exhilarating exercise. *A steam carriage will set out from Washington in the morning—the passengers will breakfast in Baltimore—dine in Philadelphia, and sup in New York the same day.*"

"To accomplish this, two sets of railways will be required, laid so nearly level as not to deviate more than two degrees from a horizontal line—made of wood or iron, or smooth paths of broken stone or gravel, with a rail to guide the carriages, so that they may pass each other in different directions, and travel by night as well as day." It is a singular coincidence that Evans should have made one of the first experiments in propelling a carriage by steam in the very city destined to become, in the course of fifty years afterwards, the head centre of one of the most important railroads in the world—"The Pennsylvania."

The Fastest Railroad Trains in the World.—As there has been considerable discussion of late as to which road runs the quickest trains, I have collated from the different time tables and other sources the best time made, that the community at large may know what is being done both at home and abroad. England stands first, both as to the number and the quickest runs, as follows:

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*A paper read at the Stated Meeting of the Franklin Institute, Wednesday, December 17, 1884.

A Summary of the Fastest Trains in the World.

Name of Road.	Between	Distance in miles.	Time. H. M.	Running average.	Number of trains.
Baltimore and Ohio	Baltimore and Washington	40	·45	53⅓	2
Manchester, Sheffield and Lincoln	Manchester and Warrington	16	·18	53⅓	16
Great Western	Paddington and Swindon	77⅛	1·27	53	4
Great Northern	Hitchin and Peterborough	44¾	·50	53	1
"	Grantham and Doncaster	50½	·58	52¼	1
"	Grantham and London	105½	2·04	51	2
"	Grantham and York	82½	1·39	50	2
North Western	Northampton and Willesden	60¾	1·10	51¾	1
"	Rugby and Willesden	77¼	1·32	50⅓	1
Midland	Liverpool and Stockport	37½	·45	50⅔	4
"	London and Kettering	72¾	1·27	49¼	1
"	Bedford and Kentish Town	48	1·00	48	10
"	Leicester and St. Pancras	99¼	2·07	47	1
North Eastern	York and Darlington	44¼	·53	50	1
Caledonian	Carlisle and Beattock	39½	·48	49⅛	1
"	Carlisle and Carstairs	73½	1·31	48½	1
Bound Brook	Trenton and Bound Brook	27·1	·31	50½	1
"	Jersey City and Philadelphia	89·4	1·52	47·9	2
"	Philadelphia and New York	90·4	2·00	45·2	2
Pennsylvania	Germantown Junction and Jersey City	84·3	1·44	49·4	2
"	Philadelphia and Jersey City	89·7	1·53	47·1	2
"	Philadelphia and New York	90·7	2·00	45·2	2
North British	Polmont and Cowlairs	23¼	·29	48·6	1
Great Eastern	Lincoln and Spalding	38¾	·47	48⅝	3
Glasgow and Western	Carlisle and Dumfries	33	·42	45	1
Brighton	London Bridge and Brighton	50¼	1·05	46⅝	1
Chatham and Dover	Herne Hill and Dover	74½	1·36	40¾	1
South Eastern	London and Dover	74½	1·39	45	2
Berlin and Cologne		404	9·00	47·1	1

Manchester, Sheffield and Lincoln.—This railway runs the greatest number of fast short distance trains in the world, numbering sixteen daily, between Manchester and Warrington, a distance of sixteen miles in *eighteen minutes*; running time 53·3 miles an hour. Fourteen of the above miles are practically level. None of these are very heavy trains, and their punctuality is excellent.

Great Western.—This line is unique in its track, which is broad gauge (seven feet) from Paddington to Penzance—mixed gauge as far as Exeter—and most of its system is laid with *longitudinal* sleepers, the same as in use on our city passenger railways. It has the smoothest running track in the world, and the speed between Paddington and Swindon is the highest of any long run in England.

For years this road was far ahead in speed, the flying trains known as "Dutchman," running just as they do now about twenty years ago. In fact on June 13, 1846, an experimental trip was made by the new locomotive, "The Great Western." The train weighed one hundred tons. The train started from Paddington and arrived at Dictcot in fifty-four minutes; distance fifty-one miles, or at the rate of fifty-six miles an hour.

This company runs four express trains to Exeter, a distance of 194 miles, at the rate of 46½ miles an hour; the distance between Paddington and Swindon, 77 miles, is run in *one hour and twenty-seven minutes*, or at the rate of 53⅛ miles an hour. (The two afternoon trains are called "Zulu," because they began to run the day after the Prince Imperial of France was killed—the two morning ones are the "Dutchman.") The running average of the four Plymouth trains, *between Exeter and Paddington*, is as high as 50⅓ miles an hour (distance 194 miles), and the distance between Taplow and Swindon, which is very smooth and level, the 55 miles is covered within the hour, but as the speed is so uniform it does not attract the attention of the passengers, and they are surprised if they undertake to time it with their watches.

Great Northern.—The most of the trains on this road are very long, but they are run at very high speed with unusual punctuality. In 1880 this road ran four express trains to Leeds, which covered the distance between Grantham and Wakefield, 70 miles, in *seventy-eight minutes*, or on an average of 53·8 miles an hour, which is slightly faster than the Swindon trains above mentioned; for some reason these trains have been discontinued. Now, on Sundays, the 5·00 P. M. runs from Hitchin to Peterborough, 44·25 miles in *fifty minutes*, or an average of 53 miles an hour. This road also runs trains between Grantham and Doncaster, 50½ miles in *fifty-eight minutes*, or an average of 52·25 miles per hour every day. This road has forty-nine long runs, averaging 73¾ miles at a running average of *fifty miles* per hour. The longest run is made from King's Cross, London, to Grantham, 105½ miles in *two hours and four minutes*, running average of 51 miles an hour.

London and North Western.—This is the oldest established railway company in England, and does the largest business, it being the first built and has the lightest grades, but in point of speed is far behind other companies. The train carrying the Irish mail to Holyhead, from Euston Station (London), over this line, and dubbed years ago "The Wild Irishman," has now sunk into comparative obscruity with its rate of 42 miles an hour. Its fastest trains are between Northampton and Willesden a distance of 60¼ miles, which is covered in *seventy minutes*, an average of 51⅜ miles per hour, also between Rugby and Willesden, 77¾ miles, is covered in *ninety-two minutes*, or an average of 50½ miles per hour. There are twenty trains between Liverpool and Manchester, distance 31½ miles, in *forty-five minutes*, averaging 45 miles an hour.

English Long-distance Train.—North Western Limited Mail.
(Third Class.)

Between	Miles.	Time.	Miles per hour.
Euston.....(leave).....	.....	8·50	
Rugby.....	82¾	10·40	45
		10·44	
Tamworth.....	110	11·20	45
		11·24	
Stafford.....	133½	11·55	45½
		11·59	
Crewe.....	158	12·32	44½
		12·38	
Wigan.....	194	1·24	46¾
		1·30	
Preston.....	209¼	1·53	40
		1·57	
Carlisle.....	299¼	4·10	40·6
		4·18	
Carstairs.....	372¾	5·53	43½
		6·00	
Holytown Junction.....	389	6·27	36
		6·29	
		6·37	
Coatbridge.....	393¼	6·40	—
		7·03	
Larbert.....	409	7·07	40½
		7·21	
Stirling.....	417¼	7·24	—
		8·13	
Perth (ticket station).....	450½	8·15	40
		9·05	
Perth.....(leave).....	.....	9·55	39½
		9·69	
Forfar.....	482¾	10·28	32
		10·29	
Bridge of Dun.....	498¼	11·37	37
		11·40	
Aberdeen (ticket station).....	540¼		

Actual miles per hour.....36·4 Actual running miles per hour.....41·8

French Long-distance Train.—Paris, Lyon and Mediterranée.
(*"First Class Only."*)

Between	Miles.	Time.	Miles per hour.
Paris		8·55	
Montereau	49	10·17	36
		10·20	
Laroche	90½	11·28	41½
		11·31	
Tonnerre	122¾	12·08	41¾
		12·33	
Dijon	195½	2·24	30½
		2·29	
Macon	273¾	4·21	42
		4·26	
Lyon	314¾	5·37	34½
		6·08	
Valence	383¾	7·51	40
		7·56	
Avignon	460¾	9·45	42½
		9·50	
Marseilles	536	11·47	38½

Actual miles per hour.....36 Actual running miles per hour.....39¾

Midland.—This road is remarkable for very high speed, although it has very heavy grades to contend with. It, like the Pennsylvania Railroad, is noted for its energy in developing "through" services and the opening up of branch lines connecting with its own. The scenery on this line also, like the Pennsylvania, is grand, including some of the loveliest views in England.

A celebrated writer in England suggests that this road "should run a car with projecting glass sides and cheap fares, for factory hands, to see the sights there are between Leeds and Carlisle." Observation cars, such as are run by the Pennsylvania Railroad in this country, between Altoona and Cresson, would answer a better purpose. The views between Derby and Manchester are grand, and the panorama seen from the Westmoreland heights as you "spin" along down grade, at 70

miles an hour, are beyond description. The locomotives of this road, like those on the Pennsylvania, have nearly one-third of their time occupied in ascending very steep grades, but they accomplish their task well. The highest point on this road being 1,015 feet above the sea. There are four trains run between Liverpool and Stockport, 37¾ miles in *forty-five minutes*; running average 50⅓ miles an hour, and one between St. Pancras (London) and Kettering, 72½ miles in *eighty-seven minutes*, running time 49·8 miles an hour, and between Bedford and Kentish-Town 48 miles in *one hour*.

North Eastern.—This line is more noted for dividends than fast running, from the fact of easy grades. It has the most comfortable equipment of trains in England, and with all, the most "democratic." Its *third class cars* are so inviting that even a "dude," entering by mistake, has been known to travel from York to Newcastle without loss of respectability. This company is also "democratic" enough to "honor America's invention in regard to *brakes*; almost every train, on a small branch, has the Westinghouse automotic." The excursion rates on this line are the lowest in England. The train between York and Darlington, a distance of 44¼ miles, is run in *fifty-three minutes*, an average of 50 miles an hour. From York to Newcastle, 80¼ miles is covered in *one hour and forty-two minutes*, running average 47⅕ miles per hour. This line mounts up to 1,369 feet above the sea, on Stainmoor, where it crosses the boundary of Yorkshire and Westmoreland. This is the highest passenger route in England, and has more romantic and beautiful views than any others. These abound either on the sea-coast, from Flamborough to Berwick, or along the valleys.

Great Eastern.—This line, like the North Eastern, has fitted all its trains with the Westinghouse brake. This line follows the curve of the east coast, and is thus continually crossing (little) transverse valleys; the greatest height between Colchester and Yarmouth is only about 125 feet above the sea, near *Westerfield*.

The best long distance run is between Norwich and Doncaster, 163 miles (seaside express), in *three hours and thirty-five minutes*, a running speed of 47½ miles an hour. The fastest run is made between Lincoln and Spalding, 38¼ miles in *forty-seven minutes*, averaging 48¾ miles an hour.

London, Brighton and South coast.—Brighton being the Long Branch of England, and formerly the residence of the king of England, who, according to an act of Parliament must live within

fifty miles of London. This has been the means of making the place a popular resort. The expresses on this road, like all running to seaside resorts, have very heavy trains.

The best run between London Bridge and Brighton, 50½ miles, is covered in *sixty-five minutes*, an average of 46·6 miles an hour.

London, Chatham and Dover.—This line deserves great credit for the spirited way in which it runs over its hilly route. The 74 miles between Herne Hill and Dover is covered in *one hour and thirty-six minutes*, an average of 42¼ miles an hour.

London and South Western.—This line is almost level to *Basingstoke*, and gets steeper as it goes west. There are three expresses and thirteen long runs, averaging 47⅓ miles. The *longest* and quickest is from Yeovil Junction to Exeter 48·5 miles in *sixty-three minutes*, an average of 46·6 miles an hour.

South Eastern.—This line has steep grades except where the line runs between Tunbridge Junction and Ashford, nearly at sea level, and quite straight for 20 miles. The distance by Cannon street, London and Dover, 74½ miles, is covered in *ninety-nine minutes*, or at the rate of 45 miles an hour.

Scotch Lines.—There are three Scotch companies that run fast express lines, and they do this over a line beset with grades.

Caledonian.—This line runs fast expresses, but owing to the steep grades of unusual length, the running average is below the former lines. If a passenger wishes to see what 70 miles an hour means, he can on this line readily be satisfied, and nowhere better than here ascertain how little compensatory effect a speed of *seventy* miles an hour, down a grade of $\frac{1}{75}$, can have in making good the loss of time going *up* the other side. On this line, between Carlisle and Beattock, 39·75 miles, are covered in *forty-eight minutes*, averaging 49⅔ miles an hour, and between Carlisle and Carstairs, by the Limited Mail, 73·5 miles is spanned in *ninety-five minutes*, or an average of 48·5 miles an hour.

North British.—This line runs the Midland (England) expresses between Edinburgh and Carlisle, and also runs a local express of its own between Edinburgh and Glasgow. Between Polmont and Cowlairs, a distance of 23·5 miles, is covered in *twenty-nine minutes*, or at the rate of 48·6 miles an hour; and between Carlisle and Edinburgh 98·25 miles is run in *two hours and twenty minutes*, averaging 42 miles an hour.

Glasgow and South Western.—This line is a much easier one than

the two former, the highest point reached being only 625 feet above the sea. The Midland (England) cars are run by this line between Glasgow and Carlisle; and between Carlisle and Dumfries, a distance of 33 miles, is run in *forty-two minutes*, or an average of 47 miles an hour; between Dumfries and Kilmarnock, 58½ miles, in *one hour and eighteen minutes*, or at the rate of 45 miles an hour.

Berlin to Cologne.—By the Lehrte route, stopping for dinner at Hanover, viz., Hanover and Stendal. The distance from Berlin to Cologne by this route is 404 miles, and is spanned in *nine hours*, or an average of 47·1 miles an hour.

Fastest English Long-distance Train.—(East Coast Route.)

	Miles.	Hours. Minutes.	Miles per hour.
Glasgow.....(leave).....	.....	8·40	
Cowlairs.....	1½	8·46	
		8·48	45½
Polmont Junction.....	25	9·19	
		9·20	42
Haymarket	46	9·50	
		9·52	
Edinburgh, (Waverly Station).....	47¼	9·55	
		10·00	46
Berwick.....	104¾	11·15	
		11·20	47
Newcastle.....	171½	12·45	
		12·50	45
Darlington.....	207½	1·38	
		1·41	49⅛
York (refreshments).....	251¾	2·35	
		3·05	50
Grantham.....	334¼	4·44	
		4·50	48¾
King's Cross (London).....	439¾	7·00	

The *North British* Company runs these trains between Glasgow and Edinburgh, the *North Eastern* between Edinburgh, and the *Great Northern* between York and London.

This time table is the fast express known as the "Flying Scotsman," which also leaves King's Cross (London) at 10 A. M., stops an hour for dinner at York, and reaches Waverly Station, in Edinburgh, at 7 P. M., distance 439¾ miles.

Average miles per hour from King's Cross to Edinburgh, 48, and Edinburgh to Glasgow being 47 miles per hour.

French Fast Long-distance Train.—Paris, Orleans, Tours, Bordeaux.
(*First Class.*)

Between	Miles.	Time.	Miles per hour.
Bordeaux (Bastide).....(dep.).....	.....	7·50 8·21	42
Libourne.....	21¾		
Coutras.....	31¾	8·23 8·39	37½
Angoulême.....	82¾	9·50	44½
Ruffec.....	112	10·15 10·56	42·8
Poictiers.....	153	10·59 11·55	44
Chatellerault.....	173¼	12·00 12·30	40½
St. Pierre des Corps.....	215½	12·32 1·30	43¾
Blois.....	248½	1·35 2·20	44
Les Autrais.....	285	2·22 3·10	45⅔
Etampes.....	324	3·15 4·07	45½
Paris.....	350¼	4·10 4·56	45½

Actual miles run per hour.....39½ Actual running miles per hour.....43¾

AMERICA.

Baltimore and Ohio Railroad.—This road, in times gone by, has marked many an epoch in railroad history, and, as the first passenger railroad in the world, has ever been in the lead in important steps forward. Building its own locomotives, which for half a century have been accorded the highest place in America, with its grand motive-power, and superb equipment throughout, it makes the fastest short distance time in the United States, and second to none abroad.

This road, on its Baltimore and Washington line, forty miles long, covers the distance in *forty-five minutes*, being at the rate of 53·3 miles per hour. There are also four trains spanning the distance in *fifty minutes*, averaging 48 miles an hour.

Philadelphia and Reading Railroad, Bound Brook Division.—This road follows next in order. This line runs a train to and from New York and Philadelphia in *two hours*, including the ferrying across the North River at the former place. The distance between the cities is by this route 90·4 miles, *via* Ninth and Green streets. This distance is covered in the above time, an average of 45·2 miles per hour. The train time between Philadelphia and Jersey City, including four stops, and one change of locomotive, is *one hundred and twelve* (1 hour and 52 minutes) *minutes*, distance 89·4 miles, is run at the rate of 47·93

miles per hour; and between Trenton and Bound Brook, 27·1 miles, is covered in *thirty-one minutes*, or an average of 50 miles an hour. There are a few really fine bits of running on this line. The writer has several times averaged *seventy miles* an hour for five successive minutes from Skillman east, this portion of the road being straight for a distance of 14 miles. The alignment of this line is very favorable, none of the curves exceeding two degrees between Jenkintown and Jersey City.

Pennsylvania Railroad, New York Division.—This line also runs a train from Philadelphia to New York, distance 90·7 miles, in two hours, making one stop, including ferryage at New York, averaging 45·4 miles an hour. Between Philadelphia and Jersey City, 89·7 miles, including one stop, the time is *one hour and fifty-three minutes*, averaging 47·1 miles an hour; and between Germantown Junction and Jersey City 84·3 miles is covered in *one hour and forty-nine minutes*, or at a rate of 49·4 miles an hour.

This route is unfortunately a continuous series of curves and re-curves, ninety in number, varying from one degree (5,730 feet) to nine degrees (636 feet radius) radius.

With all these drawbacks, the Pennsylvania Railroad Company every day accomplish a speed of nearly *fifty miles an hour*, passing over the number of curves before stated, whose total curvature would describe over ten complete circles.

But in long distance runs the Pennsylvania Railroad stands first in the world. The New York and Chicago Limited train covers the the distance between the two cities, 912·2 miles, in *twenty-six and one-half hours*, including the ferryage at New York and eight stops which occupy *sixty-six minutes*, being an average running time of 36·18 miles per hour. From Chicago to Fort Wayne, a distance of 148 miles, is covered in *four hours*, an average of 37 miles an hour.

In fact, there are no such distances yet run in Europe as across the American continent by the Chicago limited. By this train the most luxurious traveling in the world is done, besides the speed is the fastest of any long distance train. This train is made up and composed exclusively of drawing-room, dining-room, smoking-room and sleeping cars, the baggage and kitchen composing one car. The sleeping car charge and "extra fare" are represented in the one "extra fare" ticket. No half "extra fare" tickets are sold; children between five and twelve years of age being required to purchase whole "extra fare" tickets, in connection with half-fare passage tickets. Extra fare tickets

include a double berth in sleeping car or seat in section of same. A double berth will hold two persons; a section contains two double berths, and a drawing-room contains two double and two single berths. Two persons desiring to occupy the same berth will be charged one and one-half the extra fare. At least one passage ticket and one extra fare ticket will be required for each double berth occupied.

The Fastest Long-distance Train in the World.—New York and Chicago Limited.

Between	Miles.	Time.			
		Hours. Minutes.	Minutes lost in ferriage & stops.	Minutes.	Miles per hour.
New York City (Eastern time)		A. M. 9·			
Jersey City	1·	9·08	8		
Jersey City		9·15	7		
Philadelphia (Broad Street Station)	89·7	11·14			
		11·25	11	119	45·4
Harrisburg	105·2	P. M. 2·05			
		2·10	5	160	39·40
Altoona	131·6	5·35			
		5·40	5	205	38·46
Pittsburg	116·7	9·00			
(Central time)		8·17	17	200	35·
Alliance	83·	11·07			
		11·12	5	170	29·26
Crestline	106·	A. M. 2·27			
		2·30	3	195	32·6
Fort Wayne	131·	6·			
		6·05	5	210	35·9
Chicago	148·	10·30		265	33·33
Totals	912·2	26·30	1·06	25·24	280·44
Average miles per hour					36·18

The dining cars are on the western plan, not restaurant cars. *Table d'hôte* meals are served at the fixed price of $1, from bills of fare, representing all the substantials and delicacies of the season, which can hardly be matched in the country for cleanliness, juiciness and variety. The smoking-room cars are supplied with easy chairs and lounges, instead of stiff pews. You can take a seat in a rattan chair made deep and with soft cushions, or take your place at a writing desk on which is paper printed with the name of the Limited Express, and with a library of books above you, and be waited upon by a wag of a black porter, who will bring in drinks of any kind, cigars and lunch, with cards and card tables at hand. A trip across the continent in one of these trains is a luxury fit for a king, and just the thing to rest a wearied merchant or official, the landscape passing so rapidly and the time made in general with great thoroughness.

Fastest Long-distance Runs in the World.—Arranged According to Distance.

Name of Road.	Between	Miles.	H. M.	Running Average.	Train.
Pennsylvania	Chicago and Ft. Wayne.	148	4·04	36·4	New York & Chicago, Limited.
"	Altoona and Harrisbu.g	132	3·20	39·5	
"	Pittsburg and Altoona	117	3·15	36	
Great Northern (Eng.)	Grantham and King's Cross	105½	2·05	51	Fast Express fr Manchest'r
Midland "	St. Pancras & Leicester	99¼	2·07	47	Down Scotch Express.
Paris, Lyon and Mediterranee	Laroche and Dijon	90	2·41	37	7·15 fr'm Paris 1st class only.
North British	Carlisle and Edinburgh.	98¼	2·20	42	Night Expr's.
Midland	Derby and Liverpool	91½	2·04	44¼	12 N. from St. Pancras.
"	Skipton and Carlisle	86¾	1·55	45·2	Night Expr's.
London & N. Western	Preston and Carlisle	90	2·10	41¼	One each way
London & N. Western	Chester and Holyhead	84½	2·	42½	One each way
London & N. Western	Rugby and Euston	82½	1·50	45	One each way
Great Northern	Grantham and York	82½	1·39	50	One each way
North Eastern	New Castle and York.	80¾	1·42	47¼	One each way
London, Chatham & Dover	Victoria and Dover	78	1·45	44¾	One each way
South Eastern	Cannon st. and Dover	74½	1·39	45	One each way
North Western	Rugby and Willesden	77¼	1·32	50½	
Pennsylvania	Ger'n Jun. & Jersey City	84·3	1·44	49·4	One each way
Great Western	Paddington & Swindon	77	1·27	53¾	Two each way
Caledonian	Carlisle and Carstairs	73½	1·35	48·5	Limited Mail.
London & N. Western	Carlisle and Carnforth	62¾	1·25	44¼	" "
Midland	Bedford & Kentish Town	48	1·00	48	All Manchester Exp'ses.
Paris, Orleans, Tours, Bordeaux	Ruffec and Poitiers	41	0·56	44	
Paris, Orleans, Tours, Bordeaux	Les Aubrais & Etampes.	39	0·52	45½	First class.
Baltimore and Ohio	Baltimore and Washington	40	0·45	53⅓	One each way

Passengers paying so unusual a rate, are as a general thing, more

exacting than first-class passengers ordinarily. The company expecting this, special notice is given to all the company's people to be considerate and patient with the passengers. This train leaves New York at 9 A. M. (eastern time), and reaches Chicago at 10·30 A. M. (central time) the next day. Returning it leaves Chicago at 4·51 P. M. (central time), and reaches New York at 7·30 P. M. (eastern time) the next day, The above time table will show how the run is made:

It will be seen by this table that the speed in America, both for short and long distance runs, is second to none obtained elsewhere.

The *average* speed in this country in long runs does not quite equal the English, but it must be remembered that our roads have heavier grades and *more* curves, the latter being of smaller radii than is allowable on England and French roads. Then, again, the law of England gives the railroad companies exclusive right over their tracks and anyone trespassing thereon is liable to fine and imprisonment. When the law in this country steps in, as in England, we will be able to far surpass her. I have been told that we are running fast enough, but speed is a means to an end, the greater the expedition compatible, with safety, the more benefit will be derived by all parties. I am, every day, also asked if there is not more danger in the running of fast trains than with slow trains. As for *safety*, the safest line is the one which is the best managed, but the one which runs the most and fastest trains, is obliged to be the best managed; thus, those who prefer *slow* trains must yet acknowledge their debt to fast trains.

Railroad mortality statistics of England and some parts of the Continent of Europe have been compiled and published in France, from which it appears that the greatest fatality occurs on the French railways:

The	French	Railroads	kill,	annually,	one	in	every..... 2,000,000
"	English	"	"	"	"	"	" 5,250,000
"	Belgian	"	"	"	"	"	" 9,000,000
"	Prussia	"	"	"	"	"	" 21,500,000
"	French	"	wound,	"	"	"	" 500,000
"	English	"	"	"	"	"	" 750,000
"	Belgian	"	"	"	"	"	" 9,000,000
"	Prussia	"	"	"	"	"	" 4,000,000

Roundly speaking, French railways kill five times as many as English. English not quite twice as many as Belgian, and Belgian nearer thrice than twice as many as Prussian, which are much the least fatal of the four.

The dining cars are on the western plan, not restaurant cars. *Table d'hôte* meals are served at the fixed price of $1, from bills of fare, representing all the substantials and delicacies of the season, which can hardly be matched in the country for cleanliness, juiciness and variety. The smoking-room cars are supplied with easy chairs and lounges, instead of stiff pews. You can take a seat in a rattan chair made deep and with soft cushions, or take your place at a writing desk on which is paper printed with the name of the Limited Express, and with a library of books above you, and be waited upon by a wag of a black porter, who will bring in drinks of any kind, cigars and lunch, with cards and card tables at hand. A trip across the continent in one of these trains is a luxury fit for a king, and just the thing to rest a wearied merchant or official, the landscape passing so rapidly and the time made in general with great thoroughness.

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North Eastern.....	New Castle and York.....	80¼	1·42	47¼	One each way
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London & N. Western...	Carlisle and Carnforth...	62¾	1·25	44¼	" "
Midland.....	Bedford & Kentish Town	48	1·00	48	All Manchester Exp'ses.
Paris, Orleans, Tours, Bordeaux.....	Ruffec and Poitiers.....	41	0·56	44	
Paris, Orleans, Tours, Bordeaux.....	Les Aubrais & Etampes.	39	0·52	45⅓	First class.
Baltimore and Ohio.....	Baltimore and Washington	40	0·45	53⅓	One each way

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exacting than first-class passengers ordinarily. The company expecting this, special notice is given to all the company's people to be considerate and patient with the passengers. This train leaves New York at 9 A. M. (eastern time), and reaches Chicago at 10·30 A. M. (central time) the next day. Returning it leaves Chicago at 4·51 P. M. (central time), and reaches New York at 7·30 P. M. (eastern time) the next day, The above time table will show how the run is made:

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"	Belgian	"	"	"	"	"	"	 9,000,000
"	Prussia	"	"	"	"	"	"	21,500,000
"	French	"	wound,	"	"	"	"	 500,000
"	English	"	"	"	"	"	"	 750,000
"	Belgian	"	"	"	"	"	"	 9,000,000
"	Prussia	"	"	"	"	"	"	 4,000,000

Roundly speaking, French railways kill five times as many as English. English not quite twice as many as Belgian, and Belgian nearer thrice than twice as many as Prussian, which are much the least fatal of the four.

PHYSICAL CONSTITUTION OF THE SUN.

By Prof. Charles A. Young.

(Concluded from page 220.)

The next picture will show better what you see in an ordinary telescope. This is Secchi's picture of a mature and well formed sun-spot. In this the centre of the spot is nearly round, and the penumbra also. You see how the penumbra is made up of filaments that point to the centre, and how portions of these filaments are broken off and seem to move in towards the centre. If you watch them in a telescope you will see them appear to sink into the sun. Most physicists think there is in the spots an eddying current, which coming up around the outer edge from below goes down in the centre. When a spot is forming or going out of sight, we find that real changes occur very rapidly, but besides these real changes as a spot passes towards the centre of the sun from the edge, apparent changes occur in the way indicated by this next pictures, seeming to show that a sun-spot is a hollow in the solar surface. When a spot is in the centre it looks as at "*A*"; as it gets towards the edge, it takes on the appearance as at "*B*," "*C*" and "*D*," and when it gets to the edge as at "*E*" you lose sight of the spot

Diagram illustrating the fact that Sun-spots are Hollows in the Photosphere.

entirely. The depth of these spots varies from twenty-five hundred to to ten thousand miles in diameter, they are anywhere from five or six thousand miles to fifty or sixty thousand miles. The first spot shown was forty thousand miles, and the second one was about twelve thou-

sand miles in diameter. You could have put the earth, Venus and all the other planets into some spots that have been observed.

Here we have a copy of the photograph by Rutherfurd, of one spot-group on successive days. Here we have it as it first came on the surface of the sun; next you see how the spot broke up; just as whirlpools in a river appear to divide into smaller ones; first the vortex will become irregular, then it will be bridged across, and then the parts will separate and form new whirls. It very often happens that a spot will break into two, but it is seldom that two will unite in one. The size of this group, the lower one in the further corner, would be something like one hundred thousand miles across, so that the smallest of these spots would be a great deal larger than the earth.

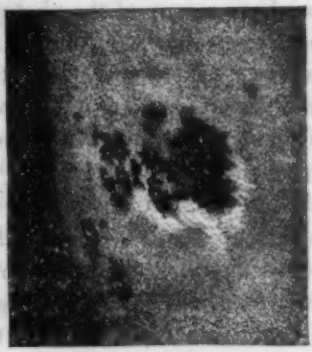
Here are some other spots taken at the Harvard College Observatory. This is the same spot on successive days; and a few days later you see it turned partly around and then broken into pieces. Here again we have a spot in the process of dissolution. As Secchi says, "when a spot is done with, the whole neighboring surface seems to fall in pell mell," and I do not know of any better way of describing the breaking up of the spot. There is a rough and broken surface in the place of the spot which has vanished.

Different theories have been held as to the nature of the spots. Galileo thought they were clouds above the surface of the sun, but that is not true. Another astronomer thought they were little planets going around the sun. The idea that they are hollows in the sun's surface came later. Herschel's idea was that the sun itself was a black habitable globe covered with luminous cloud, and that breaks in this cloud permitted us to see the dark body of the sun below. I need not say that he would not maintain any such opinion to-day with our present knowledge of thermo-dynamics. The view generally held at present, is that they are hollows filled with what may be called smoke, if you will not interpret the term too literally. Faye's theory is that they are vortices, such as would be produced by storms on the surface like the storm-centres on our own globe, producing vortical cavities in the photosphere, which cavities are filled up with matter from above, I would accept this theory without hesitation, were it not for the fact that the storm centres in the northern hemisphere would necessarily rotate in one direction, and those in the southern hemisphere would rotate in the other direction, and there is no such effect observable on the sun's surface, so that on the whole I am puzzled as to what to say as to the

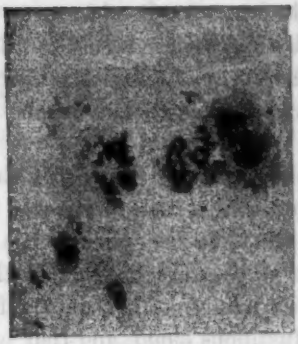
SUN SPOT GROUP ON SUCCESSIVE DAYS.

(From a Photograph by Rutherfurd.)

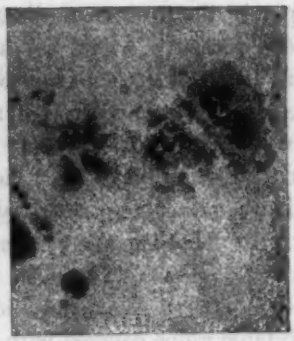
September 19, 1870.



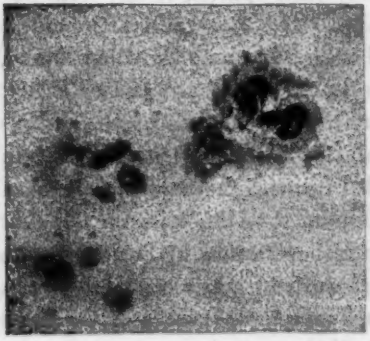
September 20, 1870.



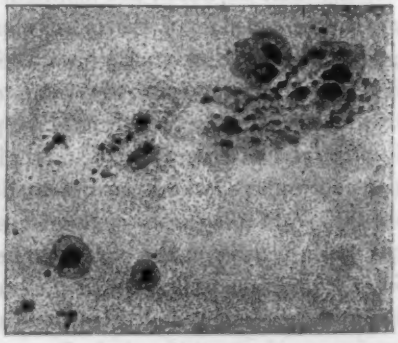
September 21, 1870.



September 22, 1870.



September 23, 1870.



September 26, 1870.

real nature of sun spots. I am certain they are cavities, but I am not sure what causes the cavities. Secchi's idea was that matter blown up from below falls back upon the sun's surface and so forms these cavities.

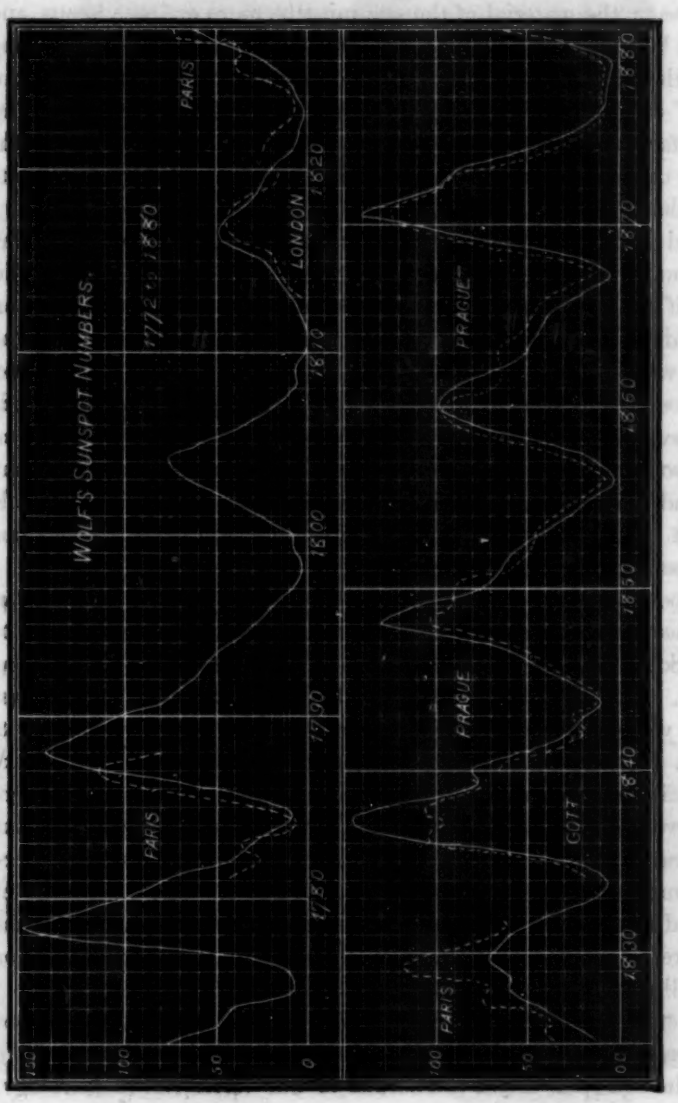
I have sometimes been disposed to think that things might happen in this way; the material of the sun must be more or less viscous, and it might be that an eruption at one point would lead to a "slumping in" of the surface somewhere else, so that spots are nothing but "sinks" caused by eruptions near them. It is still, however, a question of fact whether the hollow causes the eruption, or whether the eruption causes the spot. At present I do not think we are able to answer that.

I need hardly say to you that if the sun is sending such an enormous amount of light and heat it must be very hot; and what would happen if we had a mass of vapors heated in the centre and cooler on the outside? Of course clouds would be formed. We have on the sun the vapor of iron, the vapor of copper, the vapor of sodium, etc. On the outer surface of a great mass of such vapors a coat of clouds must inevitably be formed. These clouds will be of red hot iron, molten sodium, etc. Those clouds, probably in structure like our water and snow clouds but chemically made up of cast iron and all that sort of thing, are what shine upon us with such tremendous brightness, as the solar photosphere.

The spots have some curious ways; they do not remain regularly on the surface of the sun; they come from day to day and from week to week. Sometimes they come very frequently, and then only at long intervals. This diagram shows how they have appeared for the last hundred years; they were very frequent in 1775; there were no spots in 1777; a great multitude in 1784; none in 1788, etc. This variation constitutes what is called the periodicity of the spots. The average interval between the sun-spot years, for the past 200 years, is about eleven years; but you see there is no exact regularity about this interval. Sometimes two such years will follow each other within seven years, and then they will be separated by as much as fifteen. There has been a great deal of speculation as to the cause of this, but whether or not it will ever be discovered I cannot tell.

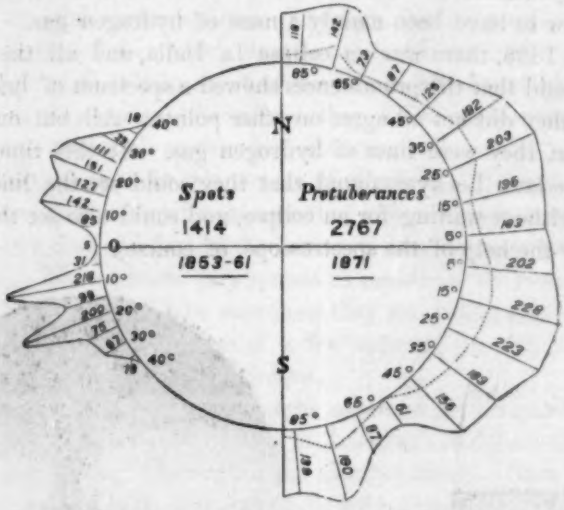
Another question is whether this spot frequency has anything to do with terrestrial events. There is quite a school of astronomers who believe the sun spots are at the bottom of our terrestrial meteorology,

so that if we watched the spots closely enough we could predict the character of the season. I do not think that is true; it is not borne out by facts. There is only one fully ascertained relation and that is seen by these dotted lines which give the record of the magnetic storms.



Wolf's Sun-spot Numbers.

The compass-needle varies in direction from hour to hour, and from day to day, and once in a while it will fly around several degrees in the course of a few hours and we call it a magnetic storm. Now it is beyond question that the magnetic storms upon the earth as observed simultaneously at various points upon the earth, have a precise parallel in the spottiness of the sun. There is a very important connection between the earth's magnetism and the solar surface; why it is I do not know.



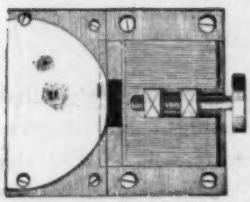
Distribution of Sun-spots and Protuberances.

There is another thing about these spots; they are not distributed alike on the surface; they are found on what we might call the temperate regions of the sun's surface; that is to say, on each side of the sun's equator the sun-spots are most numerous. This diagram shows the distribution of fourteen hundred spots between the years 1861 and 1863.

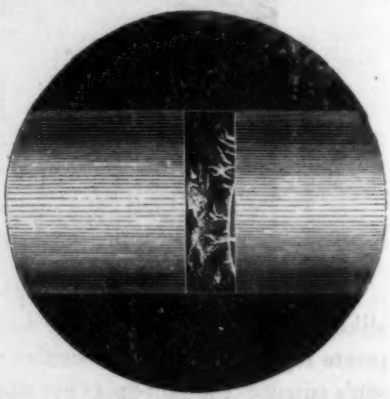
We next pass to a different topic—the chromosphere and the solar prominences. Here is a photograph of the eclipse which occurred in 1869. It was taken so quickly that the corona does not appear, but only the solar prominences. These objects had been observed nearly one hundred years before, but no one knew what they were or where they were until 1860, when photography showed that they were things on

the sun; that they were not lunar clouds, but actual appendages of the sun itself.

The next photograph shows how they were a minute later. The sun had passed on and its edge is just breaking out behind the moon, and you see that now we have the prominences on this side projecting much further than before. In the first picture all the lower part was covered; of course the second observation was enough to show that this object, thus progressively uncovered, was at the sun's surface; that thing must have been one hundred thousand miles long; it is known now to have been mainly a mass of hydrogen gas. The year before, in 1868, there was an eclipse in India, and all the different observers said that the prominences showed a spectrum of bright lines, although they did not all agree on other points. All but one or two agreed that they were lines of hydrogen gas. At this time Janssen, and a little later Lockyer, found that they could see the lines in full sunlight without waiting for an eclipse, and could also see the prominences (by the help of the spectroscope, of course).



Opened Slit of the Spectroscope.



Chromosphere and Prominences as seen in the Spectrum.

The figure represents the end of the collimator of the spectroscope and here is the slit upon which the image of the sun made by the telescope falls; the edge of the sun has just to touch the edge of the slit. By looking into the spectroscope you will see the spectrum of the sun as shown in this next diagram. I am supposing it is a very large spectroscope so that you get only a small portion at one time. The image of the slit corresponding to the *C* line, looks like a dark

band across the spectrum. Here you have a rounded rim which is just the edge of the sun, and out of that project these prominences and clouds. You can look at them at your leisure, much as though standing at the back of the room you were looking out of your window at the clouds, nearly shutting the blinds so as to see through a rather narrow crack. If you open the slit too widely everything becomes indistinct, but if you make the opening narrow it becomes clear, and you can study the picture at your leisure.

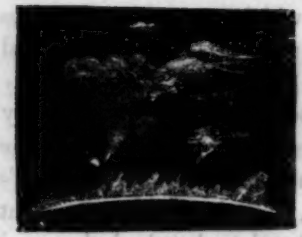
The whole surface of the sun is found to be surrounded by a rosy shell called the chromosphere. Through the photosphere rises the heated gas from below which streams out in filaments all over the sun's surface, and clothes it in a sort of fiery fur, while here and there great columns of flame arise. Sometimes they rise three hundred thousand miles above the sun's surface but not often; frequently as many at a time as you see there in this picture of Secchi's. Of course you cannot see all over the sun's surface at once, but you can hunt around the edge of the sun's disc and find in the course of half an hour all that there are there. These clouds vary almost as rapidly as the clouds upon the earth. Remembering how enormous they are, rising some sixty thousand miles high in the course of a few minutes, you can of course see that the motion must be tremendous.

Here are pictures of prominences observed at Harvard College in full sunlight. Here again is one of Lockyer's early observations, the two pictures being taken about ten minutes apart. Here are some of the forms which look like jets of liquid; I suppose they are jets of something thrown up through the hydrogen. I have not time to tell you why we could not see a jet of cast iron, while we could see a jet of hydrogen.

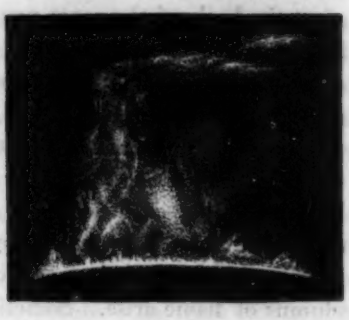
Here are formations I have observed myself. The upper one is particularly interesting since it bears on the queston frequently raised whether the sun has an atmosphere above the chromosphere; now once in a while a curious thing happens as shown in this picture. A cloud begins as a little speck and grows apparently without any connection with the sun below. Here is an example in the right hand of the diagram which shows a very rapid change. I saw this upper figure one day before going down to lunch and about forty minutes later when I came back the thing had actually blown up as shown in the picture below it. While watching it I saw some of the filaments moving visibly like the minute hand on a watch, and ascending until

QUIESCENT PROMINENCES.

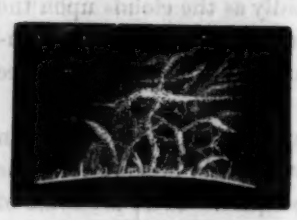
(Scale, 75,000 miles to the inch.)



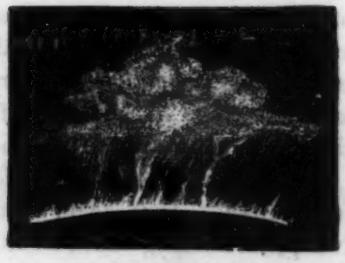
Clouds.



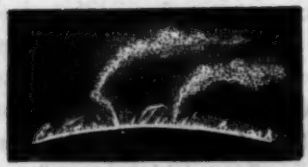
Diffuse.



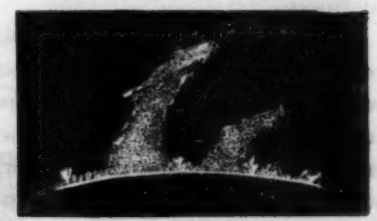
Filamentary.



Stemmed.



Plumes.



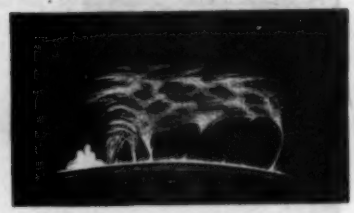
Horns.

[NOTE.—Nearly all the engravings, illustrating Prof. Young's lecture, have been reproduced from his admirable volume entitled "The Sun," which forms Vol. xxxiv of the "International Scientific Series," published by Messrs. D. Appleton & Co., of New York. For the privilege of using these illustrations, the Committee on Publication is indebted to the politeness of the publishers.—THE COMMITTEE ON PUBLICATION.]

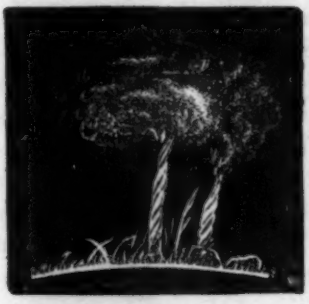
ERUPTIVE PROMINENCES.

(Scale, 75,000 miles to the inch.)

Vertical Filaments.



Prominence as it appeared at half-past twelve o'clock, September 7, 1871.



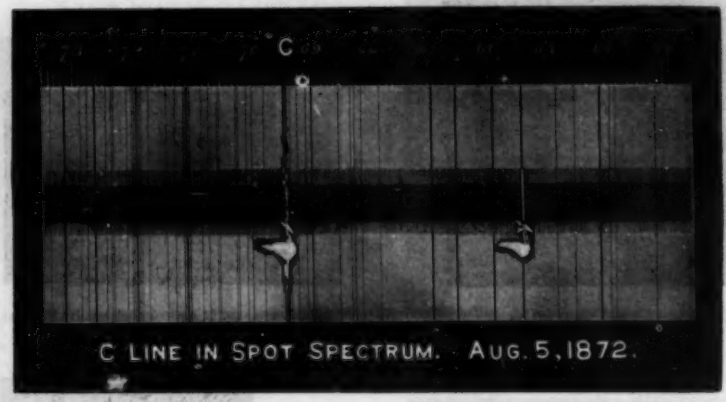
Cyclone.

As the above appeared half an hour later, when the up-rushing Hydrogen attained a height of more than 200,000 miles.

Flames.

Spot near the Sun's Limb, with accompanying Jets of Hydrogen, as seen October 5, 1871.

they vanished. They were going at the rate of two hundred miles a second. I think it is fair to call that explosive action. We cannot do anything as violent as that with explosions on the earth.



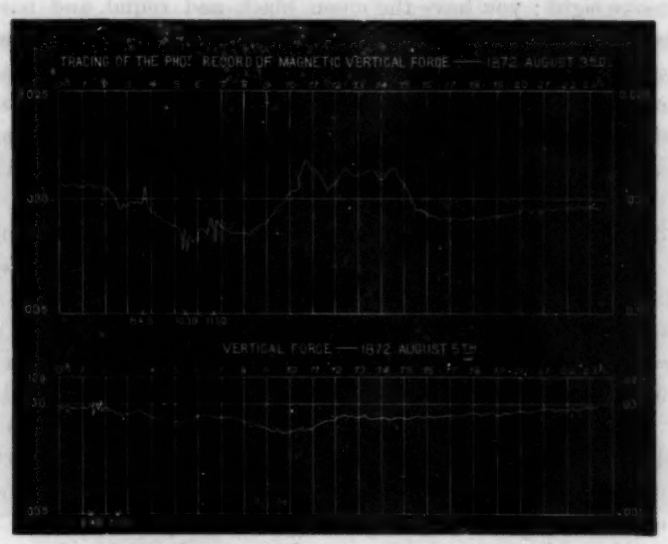
Sometimes in connection with these prominences and spots we have very curious effects on the spectrum. Here is a spectrum of a sun-spot observed in 1872; here is a dark line, the next is the *C* line of hydrogen, and here is a bright blow-pipe flame coming through it. The interesting point about it is that just at that very time there was a disturbance noticed at Greenwich and at Kew in their magnetic instruments. This diagram shows the behavior of the magnetic instruments at Greenwich. A day or two before there were great prominences there and they also showed curious things in their spectrum. Here in the upper figure is what was taking place at Greenwich: Three observations of disturbance in the prominences taken that morning were precisely simultaneous with those changes of the magnetic needle, and were thus connected with the magnetic disturbance. On the day the sun-spot appeared it was for the most part a very quiet day, magnetically speaking; but about 2 o'clock that afternoon (Greenwich time), for two hours the magnetic needle had the fever and ague; now that was the time the sun-spot was throwing out a gaseous flame, as observed by me in America. That is one marked instance showing the simultaneousness of these phenomena; and there are about a dozen such instances on record.

At the time of a total eclipse we see not only these prominences but the sun is surrounded by a peculiar halo or glow. This is a most

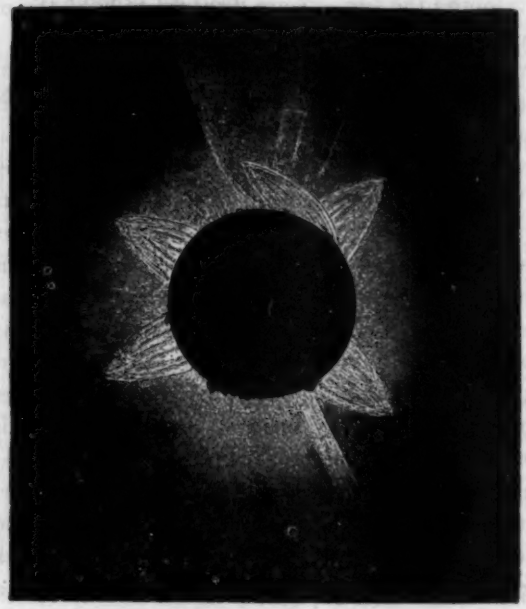
impressive sight; you have the moon black and round, and reaching out from it in all directions you have these silver rays from the sun fading out at a little distance. This figure represents it as it appeared to the French astronomer, Liais, in 1857. The peculiarity is this petal-like formation which was observed in the corona at that time.

Here is a picture that Gilman made of the corona in 1869. All the observers saw that inner portion, that irregular quadrangle, but I do not think the most of us saw those dark rays reaching out from the sun. Now what is that corona? If it is really something at the sun it must be enormous. The sun itself is eight hundred thousand miles in diameter; if this is an atmosphere around the sun it is of an enormous extent. Just at present astronomers are greatly at variance with each other as to the true theory of the corona; most of us think it is a real solar phenomenon, but there may be some optical illusion connected with it. One of our distinguished American astronomers thinks it is only an apparition, that it is mainly the effect of diffraction at the edge of the moon. The so-called corona line proves that to some extent it is a solar atmosphere or gas, but as to the main phenomenon the question is whether it is a mere optical apparition or a real halo actually enveloping the sun. I am disposed to hold the old view and think that it is a halo, and no mere optical effect.

This picture is a picture of what was observed in South Africa in 1875, and this is a photograph of the corona in 1869, taken at the same time with Gilman's picture. It however shows none of his dark rays; the best photograph ever made of the corona I now throw upon the screen, and that as you see came to grief some time ago by the breaking of the plate. It was made at Baikul, in India, in 1871; it was a very beautiful picture indeed in the original condition. You can see how far these streamers reach from the sun; the existence of the halo is almost demonstrated by the photographs made during this eclipse, because another picture of the same eclipse made in Java several hundred miles away, and several minutes later agrees with this even in minute details. Six photographs were made at Baikul at that time, and by putting them together this picture was constructed. I call your attention to one thing especially. You notice up here a curve which is convex towards the sun; if that is a real substance it amounts to a demonstration that there are repulsive forces in the sun; otherwise you could not get a curve convex to the solar surface. But all the phe-

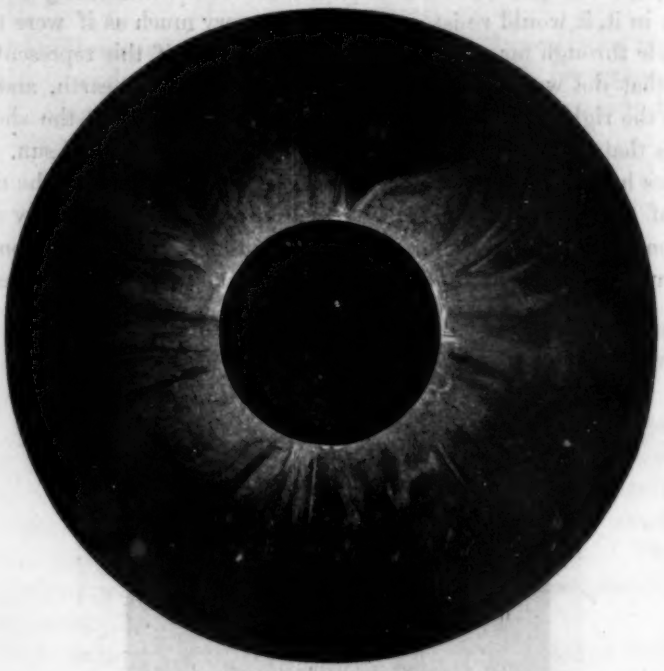


Magnetic Curves at Greenwich, (August 3 and 5, 1872.)



Corona as observed by Lialis in 1857.

nomena of comets' tails shows that in some cases the sun exercises repulsive force upon matter.



Corona of 1851. (Davis.)

This next corona picture is a picture taken of the eclipse of 1878. You see it gives even a more extensive corona than is shown by the pictures of Lord Crawford's party; but it also illustrates the difference between dry and wet photographic plates in the amount of detail. The outer portion is as clear as any picture ever made, but the inner portions have lost all their detail.

In closing, I show you a diagram that I hope will leave you with a clear idea of the structure of the sun. I will not detain you by any hypotheses of how the solar heat is obtained; it is a matter about which we do not absolutely know anything. The idea is that it is a slow contraction of the whole mass of the sun; but the only difficulty with this is that it limits the duration of the process to a few million years, it only gives us fifty or one hundred million years for the whole life of the sun.

To recapitulate; first we have within, an unknown nucleus of gaseous

matter heated intensely, in a state of vapor under high pressure, but still gas, although it is denser than water. If we were to try to move about in it, it would resist our movements very much as if were to try to wade through tar and pitch. In this diagram if this represents the sun, that dot would be about the right size for the earth, and this circle the right size for the moon's orbit. Next we have the shell of clouds that covers the whole and constitutes the surface of the sun. The cavities here, and at other places would be sun-spots. As to the thickness of this envelope nobody knows anything; It may be fifty thousand miles thick, or not more than five thousand. Though it continually rushes up the gas from below, these clouds of course are heavier

Ideal Section—Showing Constitution of the Sun.

than the gas upon which they rest, and so must settle down like rain clouds. They descend continually and force up other materials from beneath, and this up-rushing gas constitutes the chromosphere represented by this row of flames. That sheet of what we may call flames

constitutes the chromosphere, and above that are the prominences or clouds. Above all is that serene corona whose nature is still a mystery to us.

We see how much remains to be learned; we do not know what the corona is; we do not know how the spots are formed; we do not know about the atmosphere of the sun. The road is open for future discoveries, and that is all I dare say about it.

SYNCHRONISM*

By Prof. Edwin J. Houston.

Among the many practical problems whose solution has long been sought for, but sought for in vain, until very recently, is the problem of obtaining approximately absolute synchronism.

A pendulum completes its to-and-fro motion, or oscillation in a given time, that is, independent of the distance through which it swings, or, in other words, independent of the amplitude of its oscillation. The time required to make one complete oscillation being exactly the same as that required to make any subsequent oscillation. This fact is expressed when we say, that the oscillations of a pendulum are isochronous.

When we include the idea of any one event happening in exactly the same time as that required for another event to happen, we express this fact correctly by saying that the movements of the two are synchronous. That is to say, the two not only start together, but complete all parts of their motions in the same time.

In order to render the preceding clearer, let us suppose that two tuning forks be started in vibration. Either fork will continue to make isochronous vibrations, if the time required by such fork to complete any single vibration is the same as that required to complete any subsequent vibration. While the vibrations of either fork may be isochronous, it does not follow that the vibrations of the two forks are synchronous.

Either of the two forks may be isochronous in its motions, although one of the forks may make 256 vibrations per second, while the other makes 512 vibrations per second. Either of the forks is isochronous,

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* A paper read before the American Institute of Electrical Engineers, at Philadelphia, October 1884; with discussion thereon.

because it requires the same interval of time to complete any single to-and-fro motion; but the two forks are not synchronous, since one of them makes 256 vibrations per second, while the other makes 512 vibrations. In order that they may be synchronous they must each make the same number of vibrations in the same time.

The modern idea of synchronism includes the additional notion that the two bodies must not only move through the same distance in the same time, but also that their motions during the entire time must be exactly similar, that is to say, that they must be synchronous at all points during their movements.

Let us suppose, for example, that two pendulums be started at exactly the same time and be permitted to swing for, say, one minute. It does not at all follow that because they make the same number of oscillations during that time that their oscillations have been necessarily synchronous throughout the entire time of their movements, that is throughout the entire minute; since, in accordance with the definition of synchronism we have above given, it is not only necessary that the two bodies shall have moved through an equal distance, or, in other words, shall have started and stopped at the same time, but that they shall have been synchronous in their movements throughout all parts of the entire number of vibrations made.

Many attempts have been made to attain synchronism, but up to within comparatively recent date, it would seem that these attempts have been unsuccessful in obtaining the synchronism to which reference have just been made; that is the synchronous movement, for an indefinite period of time, of free moving bodies mechanically independent. For example, a ratchet wheel and cog-wheel, controlled by pawls, star wheels, friction or other mechanical devices, may be approximately synchronous in their movements, but with such movements I do not propose to treat, since they could not well be otherwise than approximately synchronous, and are not involved in a proper understanding of the term.

For example, the House Printing Telegraph, Hughes' Printing Telegraph, Calahan's Stock Printing Telegraph, Edison's Chemical Stock Printing Telegraph, Meyer's Multiplex Telegraph, Baudot's System of Telegraphy, Casselli's and Bonnelli's Autographic or Fac-Simile Telegraph, and Edison's Autographic Telegraph, are all operated by mechanically synchronized movements, which are brought into unison at given times by certain mechanical devices electrically con-

trolled, which bring them to a full or partial stop by certain mechanical impediments, frictional or otherwise, to their free motion, and these corrections being in all cases pre-arranged, are made use of whether the movement of the machine requires them or not.

Such movements, however, are not comprised in the idea of synchronism as it has been above defined, nor are they worthy the designation of synchronous movements, since their movements are never free or independent of mechanical appliances. They merely afford instances where different apparatus are maintained in a somewhat approximate synchronism for a very brief interval, when they are stopped, brought into unison and again started.

A considerable stride in the direction of true synchronism was made by Prof. Paul La Cour, of Copenhagen, whose genius has created the phonic wheel, a contrivance by means of which a rapidly interrupted circuit in an electro-magnet keeps in even rotation an armature wheel the impulses of the magnet being made effective by increments so fine on the armature wheel, that a uniform movement, hardly attainable by any other known device, is produced.

In strong contrast with the previously mentioned efforts towards synchronism, we have to-day the practically perfect synchronism of Mr. Delany, who, with marvellous ingenuity, has succeeded in obtaining and maintaining synchronism in the highest and best sense of the term.

I will be better understood when I call your attention to the fact that he has succeeded in keeping two bodies, separated by hundreds of miles, in synchronous rotation for periods of upward of seventy hours, without variation during that time of the $\frac{1}{1000}$ part of a second. This is equivalent to two entirely independent bodies separated from each other by hundreds of miles, starting together and passing through a distance of nearly one hundred miles without varying the $\frac{1}{100}$ part of an inch in that entire distance, or the $\frac{1}{1000}$ part of a second during that entire time.

The period of seventy hours I have mentioned, has no significance, so far as the limit of time is concerned, since these movements can be maintained for weeks, or months, or even for an indefinite period, with a like degree of accuracy; it being only necessary to keep the voltaic batteries, used in this system in working order.

Mr. Delany has chosen for his system the phonic wheel of La Cour

as affording the movement the best suited for regulation by his synchronizing device.

I will pass over the results he has already obtained in the shape of multiplex telegraphy, which, as you are probably aware, has been in successful practical operation under his system for some months past. In this system, circuits ranging in number from six to seventy-two, according to their capacity, have been obtained over a single wire, admitting of the transmission of from six, to seventy-two separate messages, at practically the same time, either all in one direction, or any portion of the whole number in opposite directions. These circuits so obtained may be adapted to the Morse system or to the printing system, the Morse system being applicable up to twelve circuits at the ordinary rates of transmission; the speed of any number of circuits being dependent on the number of connections that any particular instrument gets with the line in a given time.

The operation of the Morse system by the Synchronous method involves a feature that has probably never been explained, and to it I will therefore call your particular attention. If we consider that for one complete rotation of the synchronized distributor, which constitutes one end of the line, the line passes over 72 contacts, which may be used for the transmission of messages, and, that under the sextuplex organization, each of the six operators' instruments would be connected to twelve of these contacts in the circle, and that the distributor rotates at the rate of $2\frac{5}{6}$ times per second, we will find that each of the six operator's instruments would be connected to the lines 12 times for each complete rotation, or 34 times per second, and that all these operators have been put in connection with the line, and with their correspondents at the distant ends, through the synchronized distributor at that point, 34 times in a second. Now while one operator is making the shortest character or letter in the Morse alphabet, which is the letter *e*, consisting as it does of a single dot, let us see what takes place while this single dot is being transmitted. Let us imagine that when the first operator touches his key, and depresses it for the shortest interval of time that he is capable of holding it depressed, the distributor with its trailing finger, which is the end of the line, passes over one of the 12 segments connected to this operator's instrument, and transmits to the other end a portion of this single dot, but does not complete it until the other five operators have been placed in connection with the line, and the second, or third segment of the first operator's circuit has

been touched by the trailing finger when the single dot representing the letter *e* is completed. Thus one dot is made up of two, three, or more shorter impulses, which manifest themselves on the polarized relay at the distant end, as one short signal, notwithstanding that portions of letters or characters have been transmitted by five other operators between the time of the beginning and the completion of this single dot. This is an irrefutable evidence of a synchronism that has never before been more than contemplated as but a remote possibility.

The operation of the printing instrument by this system is another illustration of the degree of perfection of Mr. Delany's synchronism, that is hardly less striking than the foregoing; since if seventy-two printing instruments are used, each instrument must be dependent on a single segment for its messages, and an instrument at each end of the line being connected to a single segment correspondingly located, the distributor must connect the line with those single segments at precisely the same instant, otherwise no impulse for the indication of a letter on the type wheel will be received. Theoretically it might be supposed that the transmission of a signal, say from Philadelphia to New York, by an instrument connected to a single segment would not necessarily require that the trailing finger in the New York instrument should be on the corresponding single segment at the time that the signal was sent into the line at the Philadelphia end. Or, that the trailing finger on the New York instrument might be one segment behind the segment corresponding to the segment on which the signal was sent into the line at Philadelphia, and that still that the signal could be received on the corresponding segment in the New York instrument, since the time required for that signal to pass and manifest itself in New York would be sufficient to allow the New York instrument to reach the segment corresponding to the one from which the signal was sent into the line from Philadelphia. The fact that it takes time for the transmission of signals according to the distance and other conditions not necessary to discuss here, no one will dispute, but, that this time admits of variation of movement or departure from synchronism in Mr. Delany's machine, is disproved by the machines themselves; for, if another instrument be connected to the next adjoining single segment in each machine, and a signal be sent from New York to Philadelphia immediately after, or within about the $\frac{1}{500}$ part of a second afterward, the signal from New York is received in Philadelphia as perfectly as that from Philadelphia was received in New York

thus, showing conclusively that the conditions of variation before referred to could not have existed, since otherwise no signals could be received from New York or Philadelphia, over the second segment, as the Philadelphia instruments would have left the segment before the signal could have been completed on the segment in the New York machine and transmitted to Philadelphia.

Probably the most extraordinary proof of practically absolute synchronism was demonstrated by the experiment recently made by Mr. Delany over the line between Boston and Providence, whereby a single dot was transmitted from Boston to Providence and automatically repeated back and forth over the same wire at practically the same instant of time, travelling over different circuits in rotation backward and forward for the duration of five minutes, during which time it traveled four hundred and fifty thousand miles, this time, of course, being almost wholly represented by the movement of the armatures of the instruments. When we consider, however, the conditions involved in the transmission of a single dot, as in the case of the letter *e*, already referred to, the extent of perfection of the synchronism obtained will be understood.

Before concluding, I desire to call your attention to some contemplated applications of the wonderfully complete synchronism of Mr. Delany which he has conveyed to me. Among some of these may be mentioned fac-simile transmission, or the reproduction of signs, characters, or hieroglyphics. For instance, a fac-simile copy of a dispatch, or drawing of a map, or a pen portrait of an individual may be transmitted to any distant point. The prime condition necessary being synchronism, the time is probably not far distant when the civil authorities can render the identification of criminals almost certain by having their portraits in the hands of an officer on the arrival of the train upon which the criminal has fled. Or, a newspaper in these days of enterprising journalism, many have transmitted for publication a sketch of a great public disaster, or of any other event calling for illustration.

In conclusion, permit me to say that the invention by Mr. Delany of practically complete synchronism would appear to go no little way towards the solution of a problem that stares practical men so squarely in the face. I allude to the problem as to what shall be done with the electric conductors, that are strung over the houses, and through the streets of our large cities. Whether these wires are to be placed under-

ground or are to continue overhead, is a problem which in my opinion is as yet far from being solved. The increased capacity which Mr. Delany has obtained for every wire will, it is clear, greatly decrease the number of wires required for actual use, and this makes the problem referred to somewhat easier of solution.

DISCUSSION.

Prof. HOUSTON:—I would say here, however, that Mr. Delany's system is not necessarily dependent upon the phonic wheel, as he has invented an electro-magnetic motor which, when placed in connection with his automatic system of control, is capable of and containing exactly similar effects as are obtained with La Cour's phonic wheel.

Mr. Delany has very recently made an experiment on the telegraph lines of the Pennsylvania Railroad, and has sent messages from Philadelphia to New York and back again to Philadelphia. That was done last Sunday. I do not know how many relays were worked, but the system worked successfully on the Pennsylvania lines.

In concluding this paper, I may mention, that I have had some conversation with Mr. Keith as to whether or not it would be advisable to go into a discussion of the means by which Mr. Delany has obtained his synchronism, and we came to the conclusion, that the time available to us is so short, that it would not be worth while to go over the description of the means, which we can fairly suppose the members are familiar with. Mr. Keith tells me, that when he publishes this paper, he will probably reprint some of the articles that I have written, which contain a full and exact description of the methods employed. Otherwise it would be difficult to compress any description of the system into the space of an hour. I see, very fortunately, that Mr. Delany is here himself, and if there is time, I would suggest, that he be called upon.

The CHAIRMAN (Mr. W. D. Sargent):—Mr. Houston has given us a very interesting paper. As I understand, Mr. Delany is here, and our time is limited—but we would be glad to hear from Mr. Delany.

Mr. DELANY:—I don't know that I have anything to say, unless some persons, not understanding the theory and principle of synchronism, would like to make inquiries, if so, I would be very glad to respond.

So far as an explanation of the system is concerned, I think it would be much more satisfactory, individually and collectively, if we would

go to the exhibition and see the system in operation. There every facility is at hand to make a much clearer explanation as to how it is done, and that certainly would be much more satisfactory than anything I would attempt to do here. However, if any of the gentlemen have anything to inquire about, I would be very glad to enlighten them as far as I can. I take pleasure in extending to the gentlemen of the conference here a cordial invitation to come out and see our system in operation in the exhibition building. We will be there during the week, and when they come, if they will make themselves known, I shall take particular pains to show it to them.

The CHAIRMAN :—Your apparatus in that building is simply working in the building?

Mr. DELANY :—We have no outside facilities at all. On Sunday we worked, from Philadelphia to Jersey City and back, over the Pennsylvania wires with a No. 9, and a No. 8, wire. One was an old wire, I don't know its electrical condition, it seemed to be in pretty good order.

Mr. MAILLOUX :—You are working through an artificial resistance, are you not?

Mr. DELANY :—Yes, our battery is very limited, consequently we are restricted to a lower resistance. On Sunday we had the Pennsylvania Railroad batteries, so we were able to work through to New York and return.

Mr KINTNER :—What is the longest circuit you have worked?

Mr. DELANY :—We worked a year ago over the American Rapid Line from Boston to New York. We had then only progressed as far as the quadruplex.

Mr. KINTNER :—Do you find any static trouble over that distance?

Mr. DELANY :—There we had static trouble, but it was overcome.

Mr. KINTNER :—By ground contacts?

Mr. DELANY :—Ground contacts. This was entirely practical. The ground contacts afforded us a mechanical remedy for getting rid of the static troubles within our reach. For a longer distance, it would only be necessary to make the ground contacts a little larger.

Mr. KINTNER :—I was thinking of that.

Mr. DELANY :—Or larger than the contact connected with the operators' instruments. Of course such an enlargement would to a certain extent be at the expense of the operator's contact. If we have

ground contact about the same size, so the line will have the same duration with the ground that it had with the operator's instrument we can work very satisfactorily. The circuit referred to was 250 miles, over a No. 8, galvanized iron wire. If it is necessary to work further over that kind of a wire, we will probably have to put in repeaters or use a copper wire.

Mr. KINTNER:—Have you ever tried the condenser?

Mr. DELANY:—We could not use that very well; we could not apply the condenser, because our currents are constantly being reversed. We use polarized relays. So while it would assist in one instance, it would create a difficulty in the other.

Mr. KINTNER:—I had forgotten about the polarization.

Mr. DELANY:—We have worked successfully through three repeaters, and have worked through five; it was simply only necessary that the sounder of one circuit should become the transmitter in another circuit.

The CHAIRMAN:—To what extent is your system dependent upon the electrical condition of the conductor between the two ends?

Mr. DELANY:—We have but very little difficulty from that cause. Synchronism is maintained, if we get sufficient current over the line to actuate the armature of the correcting relay, adjusted in the most sensitive way, the armature of the electro-magnet is adjusted by a delicate spring, so as to keep the armature against the back stop. If we get a sufficient current over the line to move the armature from the back stop, we can synchronize. In fact we can synchronize further than we can telegraph. Any ordinary change in the condition of the line does not affect us at all, because frequently we have put three or four thousand ohms of resistance into the line, and taken it out suddenly without affecting our synchronizing apparatus. With polarized relays and reversed current, a fluctuating condition of the line does not affect us as it would an ordinary relay. It is simply a question whether you get sufficient current over the line to actuate the most sensitively adjusted relay. As long as we can do that we can work.

Mr. MAYNARD:—Is it possible for these machines to get out of synchronism?

Mr. DELANY:—Oh, yes.

Mr. MAYNARD:—What do you do then?

Mr. DELANY:—They come in of themselves, if you let them alone within two minutes. The correcting impulses sent over the line will

correct a discrepancy in vibration of the forks of about five vibrations per second. If you should open a wire between the two stations, the instrument would then have to run independently, they would get out of synchronism within a minute or two. The instrument may be locked up and not be accessible to anybody. If they should be thrown out of synchronism they would come to that point again of themselves.

Mr. MAILLOUX:—Do you maintain the line of circuit so they can keep themselves in a synchronal condition?

Mr. DELANY:—Oh, yes; the line of circuit is always closed, subject, of course, to interruptions of the commutator from the circuit table.

Mr. MAILLOUX:—I mean when the operator wishes to send a message in the ordinary way, he does not have to wait until the line is synchronized.

Mr. DELANY:—He has to wait until the line is synchronized to send the message; if he did not, the message would not reach the operators in connection with that circuit at the distant end.

Mr. MAILLOUX:—When the machine is in use on the line, I wish to inquire whether the machine is maintained in a synchronized condition?

Mr. DELANY:—It is always maintained in a synchronized condition. Each operator's instrument is always to the ground, so that if the operator at the other end of the line closes his key, it is manifested directly to the corresponding operator at the distant end.

Mr. MAILLOUX:—It is your purpose, is it not, to maintain that local circuit in action all the time, so that the phonic wheel is moving all the time at either end?

Mr. DELANY:—Always; at night we shut them down if there is no longer necessity for running them.

Mr. MAILLOUX:—You open in the morning and synchronize?

Mr. DELANY:—After we start them in the morning they run all day.

Mr. MAILLOUX:—With the ordinary Morse system how many transmissions can be made practically and profitably over one wire?

Mr. DELANY:—We make six transmissions by the Morse at the highest rate of the ability of the operator. That is, you can send forty words per minute—we have transmitted from Providence to Boston, and Boston to Providence and back to Boston by a line, which I sup-

pose is a circuit of about 100 miles, very close to 1,000 words on the sixth of a wire, *i. e.*, when the wire was distributed sextuplex, at the rate of from 43 to 44 words per minute. I received myself over a twelfth of a wire, eleven hundred words, at an average of twenty words and a fraction. It is equal to 18 or 20 words beyond a doubt.

Now as to the commercial advantages of either the six, or twelve divisions of the segments, that is a question. For commercial telegraphy I suppose that between two offices doing an ordinary telegraph business, the six circuits could be worked to the best advantage, because it requires the less number of operators to the circuit, and each circuit is equal to the best ability of the most expert operator. But for renting purposes, you may rent twelve circuits to a greater advantage than the six; beyond the twelve we have to abandon the Morse system and use 'Printers.'

WATERPROOF CEMENT FOR PAPER.—Labels can be attached to tin-boxes, or to other metallic surfaces which are exposed to dampness, in the following manner: Dilute white of egg in an equal quantity of water, or dissolve dry commercial albumen in two or three times its weight of water and apply the liquid with a brush upon the two surfaces which are to be joined. Iron the surface with a hot smoothing iron. By joining successive layers of paper in this manner, paper boxes may be made, which will be waterproof.—*Jour. d' Horlogerie; Les Mondes*, April 12, 1884. C.

A MINING PROBLEM.—The *Bulletin des mines* records the explosion of a heavy blast of dynamite which produced but little effect. The failure was attributed either to an insufficient charge, on account of the exceptional hardness of the rock, or to a crevice by which a large portion of the gases had escaped. Neither of these reasons, however, was the true one. One of the two halves of the original charge had remained unexploded in the rock, and it went off, some days afterwards, at the moment when several other blasts were exploded in the neighborhood. Fortunately no one was injured, but the consequences might have been very serious if the explosion had occurred while the miners were in the quarry. It is obviously an important problem to determine how best to ascertain whether all the charges of a blast have been really exploded.—*L'Electricien*, June 1, 1884. C.

MOTION OF THE SUN.—It has been hitherto supposed that the solar system is moving towards the constellation Hercules; but the investigations of Prof. Plummer, of Oxford, lead him to believe that the point towards which we are moving is nearer the constellation Lyra than has been generally suspected. As it is not likely that the sun describes a straight line in space, it becomes important to collect all possible information which may help us to ascertain the exact form of its orbit.—*La Nature*, May 31, 1884. C.

AN EXPERIMENT IN WEATHER FORECAST.

By Pliny Earle Chase, LL.D.

[Read before the American Philosophical Society, January 16, 1885.]

The class of '88, in Haverford College, have studied Chase's Elements of Meteorology, with a special view to the formation of trained habits of observation. They have acquired such skill in local weather forecast* that they undertook, early in December, to predict the probable regions of fair and stormy weather for all parts of the United States, on Christmas and New Year's days. The predictions were forwarded to Washington and submitted, through the courtesy of Gen. W. B. Hazen, Chief Signal Officer U. S. A., to the Board of Indications, to ascertain the degree of accuracy.

The following were the grounds of forecast:

1. The mechanical influence of solar and lunar tides on atmospheric currents, which has been tested by sixteen years' investigation and observations at Philadelphia and Haverford College. The normal tendency of tidal pressure, independent of friction, polar and equatorial currents and other disturbing influences, is from the East at syzygy; from the South at the following octant; from the West at quadrature; and from the North at the following octant: thus forming a lunar wind-rose, of a like character to Dove's solar wind-rose.

2. The normal percentage of average lunar rainfall on the several days of the lunar month, as deduced from three years' observations of the Signal Service Sergeants (Proc. Amer. Phil. Soc., xiv, 416–8).

3. The Signal Service tables of the winds which are most likely, as well as of those which are least likely, to be followed by rain or snow in each region, during each month of the year.

I had previously stated (Elements of Meteorology, Part i, p. 95), that "a verification of lunar forecasts in five cases out of nine should be regarded as satisfactory. In favorable localities, if due regard is paid to temporary local influences, predictions may often be made for a month in advance, which will prove true in three cases out of four." The reports which were received from the Signal Office were examined in several different ways, the lowest mean verification of lunar influ-

* The verifications, after two months' study, ranged between 74 and 90·3 per cent., the general average being 81·5 per cent.

ence for the two days being 59 per cent., while the highest was 100 per cent., as is shown by the followings tests:

I. TESTS OF LUNAR INFLUENCE.

α. The tri-daily bulletins of the Signal Service Bureau, show that in 13 of the 22 regions, or 59·1 per cent., there were such differences of barometric pressure between the two days of observation as should be produced by tidal influence, viz., increased pressure when the normal currents are retarded, diminished pressure when they are accelerated.

β. The normal relation of temperature to pressure (thermometer rising when barometer falls, and *vice versa*) was shown in 17 of the 22 regions, or 77 per cent.

γ. The tendency to partial reversal of surface currents by friction, in passing over the land, and consequent partial opposition of lunar influence,* was shown in 19 of the 22 regions, or 86 per cent.

δ. The rainfall on Christmas day was 1·07 times as great as that upon New Year's day. The lunar normal ratio was 1·04. This represents a verification of 97 per cent.

ε. The influence of "favorable localities," independent of any regard to "temporary local influences," was shown in the Middle Atlantic States, where the verification was 100 per cent., the weather at every station, on each of the days, being such as was foretold.

II. TESTS OF SOLAR INFLUENCE.

ζ. The special report of the Board of Indications, showed a verification of 70·7 per cent. for the fair forecasts; and a rainfall, in amounts sufficient to be measured, in 25 per cent. of the regions for which stormy indications were foretold. The full significance of this test cannot be satisfactorily determined, because the normal proportion of stormy winds which bring actual rainfall has never been published.

η. The forecasts which were authorized by the Signal Service tables showed a verification of $1{,}275 \div 19 = 67{\cdot}1$ per cent. on Christmas day, and of $575 \div 15 = 38{\cdot}5$ per cent. on New Year's day, or a general mean of $1{,}850 \div 34 = 54\ 4$ per cent. In three of the regions at the former date, and in seven at the latter, no forecasts were

* Elements of Meteorol. Part i, pp. 93–5, Par. 1, 8; Proc. Amer. Phil. Soc. xi, 113.

prescribed by the tables, the wind-deflecting tendencies being from doubtful azimuths. This test, like the foregoing, is affected by the uncertainty as to what constitutes a satisfactory verification of storm-forecasts which cover winds from one-half of the azimuths.

θ. As nearly as could be ascertained from the tri-daily reports, the stormy indications in the Signal Service tables were verified in 65 per cent. for the fair winds, and there was measurable precipitation after 43 per cent. of the stormy winds, the general mean verification being 60 per cent. This would indicate a verification, according to the preceding test, of $54.4 \div 60 = 90.7$ per cent.

ι. The ratio of lunar to solar monsoon influence, which was shown in tests α and η ($59{\cdot}1 \div 54{\cdot}4 = 1.086$) agrees very nearly with the ratio which was shown by the winds at Haverford during the past year ($545 \div 514 = 1.06$). Of 1,059 observations, 545 were nearer the azimuth which represented the lunar tidal tendency and 514 nearer that which represented the solar monsoon influence, as given by Coffin (Winds of the Globe, p. 431). This degree of accordance seems to justify the belief that the subsidiary value of lunar normals would be found as great elsewhere as it is at Haverford, for detecting and co-ordinating the abnormal influences of equatorial or polar, cyclonic or anticyclonic, local or general currents.

III. TESTS AT HAVERFORD COLLEGE FOR 1884.

$\varkappa$. Tidal acceleration of atmospheric currents was accompanied by low barometer; tidal retardation by high barometer.

λ. The percentage, both of stormy winds and of cloudiness, was greater in the lunar stormy cycles than in the fair cycles.

μ. Of the 120 days on which the lunar tidal tendencies were more stormy than fair, 54 were accompanied by measurable precipitation; on 32 other days there were winds from stormy directions; 11 others were cloudy, and on 23 days no special evidence of stormy disturbance was recorded. This represents 81 per cent. of verification by storm or stormy tendency, and 19 per cent. of failure.

ν. Of the 120 days on which the lunar tidal tendencies were more fair than stormy, 74 were fair; on 21 other days there were winds from fair directions, and on 25 days there was rain or snow with no special record of fair influence. This represents 62 per cent. of complete verification, 17 per cent. of partial verification, and 21 per cent. of failure.

ξ. Making allowance for one day's possible shifting of fair and stormy tendencies, by the acceleration of equatorial cyclonic currents, or the retardation of polar anticyclonic currents, 85 per cent. of the fair, 71 per cent. of the stormy, and 79 per cent. of all the indications were completely verified. In this test no stormy verification was admitted in which there was not an actual measurable amount of rain or snow.

o. Of the winds from stormy quarters during the year, 63 per cent. were followed within 24 hours by measurable amounts of rain or snow. Of the winds from fair quarters, 72 per cent. were followed by fair weather for 24 hours, with no measurable amount of rain or snow. The mean verification of all the wind indications was 68 per cent.

π. The comparative value of forecasts, from lunar indications which might have been foretold years in advance, and from wind indications which are good only for a day in advance, was $45 \div 63 = 71{\cdot}4$ per cent. for storm; $62 \div 72 = 86{\cdot}1$ per cent. for fair; $53 \div 68 = 77.9$ per cent. for all.

ρ. The percentage of verification for stormy indications was greatest in winter and least in summer.

σ. The percentage of verification for fair indications was greatest in autumn, and least in winter. There were marked indications, however, of a tendency toward general maximum verification in summer.

τ. The percentage of total verification was greatest in winter, when the thermal disturbance of Moon's tidal action is least, and least in summer, when the thermal disturbance is greatest.

υ. The percentage of verification, both for the fair and for the stormy indications, was greater in the equinoctial semester than in the solstitial.

φ. The conflict of solar daily and monsoon influences with lunar monthly tidal influences was shown in numerous cases of stormy anticyclonism and fair cyclonism which had been overlooked in the daily forecasts from Washington. Predominating solar influence accounted for 32 of the 46 abnormal days during the fair lunar tendencies, and 51 of the 66 abnormal days during the stormy lunar tendencies, or 74 per cent of the whole.

It would be unwise to draw any positive conclusions from the results of a single experiment, or from observations for a single year at a single station, but there is certainly encouragement for continuing the line of investigation which is here indicated.

ELECTRICITY IN MEDICINE.

By Harrison Allen, M. D.

[Abstracts from a lecture on the subject of "Electricity in Medicine," delivered at the International Electrical Exhibition, Tuesday evening, September 30, 1884.]

[The lecture, as originally delivered before the International Electrical Exhibition, included a general resumé of the applications of electricity to the study of the phenomena of life, and especially to the practice of medicine. Of necessity a subject so comprehensive when arranged in a manner suitable for a popular occasion admitted of no expression of individual views, and indeed was so treated as to give to the auditor a general idea of the importance of electricity as an aid to physiology and to therapeutics, rather than to elaborate a single theme of interest to the investigator. After reverting to the phenomena of electrical animals, the lecturer passed to the observations of Franklin on the constant current upon the living body. An account of the researches of Galvani and Volta followed, and a succinct description was presented of the uses of these varieties of electricity in medicine as contrasted with that of faradism. The applications of the incandescent wire as a cautery as well as a means of illumination of the throat-passages ensued. Examples were given of the methods of Duchenne in studying the functions of muscles by determining isolated contractions of separate muscles by the induced current as well as the method referred to Reichenbach as a means of ascertaining the effects of a powerful current of electricity) which was caused to be passed through a powerful stationary magnet) upon the sense of sight. The method last-named was held by the lecturer to have special interest at this time, since the organizations of societies devoted to psychical research would probably lead to the repetition of the Baron von Reichenbach's experiments in this country.

In selecting from this extensive range of subjects one theme which would bear elaboration, the author has concluded that an exposition of that form of electricity in the application of which he is personally the most interested, would afford the best opportunity of presenting observations which might claim to be original, namely, in the use of the galvano-cautery as an agent in the treatment of diseases of the nasal chambers.—H. A.]

LADIES AND GENTLEMEN: I desire to bring to your attention this evening a subject in which I have for a number of years felt a warm interest; indeed, to such an extent is this the case, that this lecture in great part will be a statement of my own experience. It will make no pretence to be any other than a record of my own conclusions on a subject of great practical importance.

THE GALVANO-CAUTERY IN NASAL SURGERY.

In 1873 I began a series of observations on the use of the galvano-cautery in the treatment of nasal disease. At that time the only battery available for the purpose was that of Burn's, an instrument which, notwithstanding the fact that its activity is dependent upon the immersion of the plates in a stationary bath, and the additional defect that currents of air are to be constantly transmitted through the fluid to secure efficacy, combines many advantages, among which may be mentioned its portability, the ease with which it can be cleansed, and, I may add, its durability, for the instrument at that time purchased has been in almost daily use for ten years. The greater number of these observations now recorded, therefore, were made with the Burn battery, although I have supplemented it in my practice with a larger, more efficient, yet bulkier instrument. At the beginning of my studies I was much discouraged to find that the conductors, the electrode, and the circuit maker, were all large, heavy, and imperfectly adapted for use upon chambers, so small and imperfectly illuminated, as are those of the nose. The cords were heavy and cable-like, and the electrodes adapted for the coarser purposes of surgery. In these respects they were admirably adapted (let it be understood) to all operations in general surgery, and especially to those involving vascular structures, such as the tongue. I desire to return my acknowledgments to Mr. Otto Flemming, of Philadelphia, to whom the problem was presented in 1874, to furnish for the purpose I designed, a more delicate electrode and a lighter and more available form of conducting cords. Without detaining you with the details of Mr. Flemming's efforts, aided by my own suggestions, I succeeded abont the time above-mentioned in having prepared for my use a form of electrode which has remained to this day the basis upon which all similar instruments have been made which have been used by me (Fig. 1.) The electrode is simply a pair of delicate copper wires, measuring a little over one millimeter in diameter, separated throughout their entire lengths by asbestos, except at those portions which are continuous with a terminal

platinum loop. The copper wires and asbestos are firmly wrapped with insulating silk, and the entire instrument when completed will present an average length of fifteen centimetres, a width of from two to three millimetres, and the platinum loop varying in length from three to fifteen millimetres. The weight of each one of these electrodes never exceeds 148 grains. Such an electrode is flexible, is readily cleansed, is light in weight, and is durable. The platinum loop at the end of the instrument can be modified in shape in ways already understood by electricians, and nothing novel is presented under that head. The extent, however, to which the platinum loop may be made to extend beyond the copper wires is a matter of much importance, if it is desired to make a linear eschar. It follows that the length of the platinum loop will determine the length of the eschar itself. When, however, a mere point of contact with the living membrane is desired, there is no objection to wrapping the electrode almost its entire length, thus leaving a mere tip of the platinum exposed. When it is desired to apply the cautery to the naso-pharynx, it is prudent to wrap every part of the instrument except its free end, in order that the posterior edge of the soft palate be not involved in the burn.

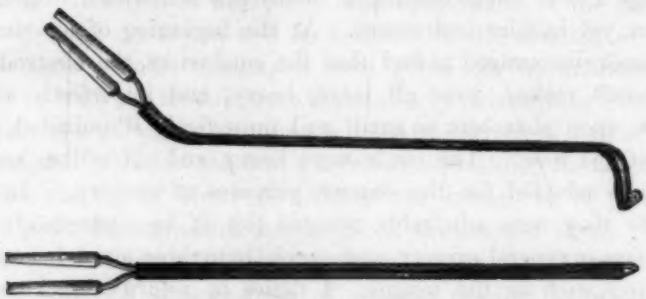

FIG. 1.—Two electrodes of peculiar shape in use by the Author.

The width of the cable with which I began my observations equalled about ten millimetres; but for the last year, I have succeeded in having very satisfactory results from a cord exactly one-half this width and of corresponding light weight. I desire next to call your attention to the battery which I have now in use, a battery designed by Dr. Carl Seiler and Mr. Otto Flemming, and known under their names. The novelty of the battery consists in the fact that the plates themselves are stationary, and the fluid is brought in contact with them by an upward motion which is determined by the pressure of the operator

upon a treadle. The advantage of this method of bringing the plates in contact with the fluid is a decided one. The moment the foot of the operator is removed from the treadle, the current ceases, and there is no danger as is so often acknowledged to exist in the use of the Burn battery, of neglecting the plates and allowing them to remain in immersion a longer time than is needed.

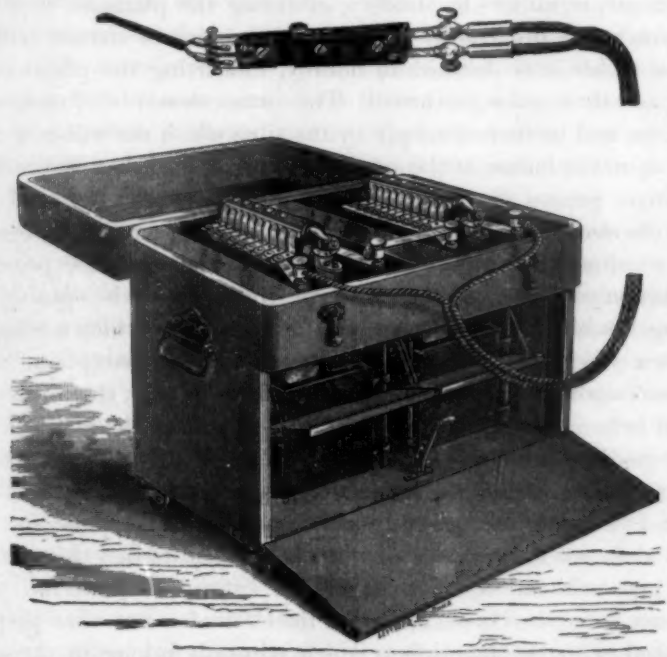

FIG. 2.—The double Seiler-Flemming battery employed by the Author. The two sets of plates are seen united by a flat band of metal. The case inclosing the two separate batteries opens in front, displaying the cells. The plates (which are seen pendant over the cells) and the treadle are shown. Above the figure of the battery lies a figure of the Flemming electrode-handle and the electrode in position.

We have in this apparatus an exceedingly powerful agent, especially when the battery is made of double strength, as I have of late been using it (Fig. 2); that is to say when two batteries (each one representing the chemical strength of that instrument known as the "Seiler-Flemming Battery," worked by a single treadle are united. A current from this powerful instrument is passed into a single short loop of platinum wire, and develops a heating effect of the highest destructive power. Yet the degree of heat is so rapidly evolved as to produce the desired effect upon the membrane with the least amount of pain. It may be held

as an axiom in the application of the galvano-cautery, that the pain of an application is in direct ratio to a low degree of incandescence; or, expressed differently, the ease with which the applications can be borne is in direct ratio to the scintillating appearance of the loop and of the white color which attends incandescence. The single disadvantage associated with the employment of the white scintillating incandescence is the danger, or rather the liability, of fusing the platinum wire; but this can be readily averted by bringing the wire in contact with the tissues which it is destined to destroy, immersing the plates in the fluid, and then making a current. The contact should be of momentary duration, and be limited simply by the time which the will-power can press upon the button at the side of the current-maker. The moment the finger presses the button inward there is a quick flash of light from the electrode; the instant it is removed, the wire again becomes of the ordinary appearance of platinum; so that while the process of destruction is going on, the finger of the operator is opening and closing the circuit very much after the manner in which a telegraph operator works the Morse indicator. With one exception, which followed upon the incautious pressure of the button, thus making a circuit before the battery fluid was raised up against the plates, I have never fused a platinum loop. In the instance named the short interval of time which intervened between the appreciation of intense heat, which I had thus inadvertently maintained in the loop, and the time required for me to break the circuit was sufficient to fuse the wire.

It goes without saying that with a battery so powerful, great prudence is required in manipulating the electrode; but when properly used and with the precautions which naturally belong to the use of all surgical agencies whatsoever upon the living economy, I can say that the galvano-cautery in the treatment of nasal disease is absolutely safe. The single point which may be urged—that is to say, one which at least came to me with a sense of surprise—was the effect upon the tissues at the side of the platinum wire not in contact with it, but simply in its neighborhood. The tissues were thrown into a state of high vascular excitement by the presence of the heated loop near them; and one can very readily understand that the amount of radiant heat thrown off to the membranes in their immediate proximity from the heated wires would produce a roasting effect if long maintained in one position; but fortunately, almost all effects desired by the use of the cautery are obtained quickly; and two or three flashes of heat from

the electrode, while it destroys the tissues which are in contact with the loop, do not have, in a chamber so moist as is that of the nose, any deleterious effect upon the adjacent surfaces. One of the most annoying effects in the use of the heated wire, is noticed in the removal of tumors from the roof of the naso-pharynx; for in this region the contact of the heated wire at the base of the growth is at the same time in close proximity to the structures at the orifice of the Eustachian tube, and the destruction of the tumor may go on coincidently with the roasting of the membranes at this orifice; but even in this instance the heated wire need be maintained for a short time only, as the loop is narrowed, it passes more and more toward the median line of the naso-pharynx and is to a corresponding degree, removed from the neighborhood of the tube.

The ease which the surgeon possesses of making eschars with this instrument, exposes him to the peculiar danger of attempting to do too much at a single sitting, and to hasten a treatment, otherwise tedious, by too often repeated or too deeply made applications. If the surgeon is desirous of reducing tumorefaction or swelling, I believe it is a rule, which should never be departed from, that the employment of extreme caution, producing slight effects with the wire at intervals of at least one day or two days apart, endeavoring to use the white heat in such a way as not to draw much blood, in other words to destroy the superficial or epithelial surface rather than the deep connective tissue or matrix, produces the best result in the long run. If, however, it is necessary to remove enlarged masses, the cautery-snare had best be employed in place of the electrode, (see p. 318). The slightest contact of the wire against the epithelium will at once carbonize the surface, while at the same time it will coagulate the albumen in the membrane beneath it. In this way, an effect is secured which is in every way comparable to that produced by caustics of the chemical group, such as nitric acid, etc.; whereas, if the destruction is deeply effected and hemorrhage ensue a lesion is established and the patient is subjected to the uncertainty attending a wound.

The wound may be the site of deposition of irritating substances in the air, of the diptheritic deposit, and at best is the location of tenacious clot-like exudations, which from the very fact that they form upon surfaces exposed constantly to the incoming and outgoing air soon become in part dessicated, and serve as sources of irritation to the surfaces already acknowledged to be in a morbid state. Whereas, if

the surgeon is content to produce localized death by making firm coagula of albumen, these will be thrown off slowly (say from three to five days) and will leave beneath them a healthy surface, which, as a rule, does not a second time form an eschar. A small surface being covered at a single sitting, permits the operator to make applications to adjacent areas, without waiting for an eschar to come off from a given surface. I have often at a single sitting produced slight eschars in both right and left nasal chambers, the roof of the pharynx, and the tonsil. As a rule, however, it is desirable to make an application to one spot only at a single sitting.

In the order of the locations to which applications are to be made, may be mentioned first, the under surface of the middle turbinated bone, which can readily be reached by a small straight cautery, the head being thrown well back on the shoulders; second, the under surface of the inferior turbinated bone, which can be reached by a large straight electrode, the head being held in an easy position, and the floor of the nose being horizontal to the axis of the body; third, the roof of the naso-pharynx, which can be readily reached, either by thrusting an instrument directly through the nose into the pharynx, or by bending one at a convenient angle, and permitting a small amount of platinum wire to be exposed; fourth, the tissue at the outer side of the middle turbinated bone, corresponding to the region at which the maxillary sinus communicates with the nose; fifth, the region at the sides of the pharynx, and the orifice of the larynx. One of the most interesting of such methods of application is that of reaching the roof of the naso-pharynx through the nose. If a perfectly straight instrument, placed into the nose, and be thrust back along the floor until it reaches an obstruction, being allowed to remain in this position, and the rhinal mirror being employed to inspect the naso-pharynx, the end of the electrode will be found resting against the roof of the pharynx; so that the roof of the naso-pharynx can be burned with absolute freedom and impunity, within the limits above named, by simply taking the electrode and forcing it through the nose as far as it will go and burning the tissue against which it rests. In this way, diseased tissues at the roof of the pharynx can be successfully treated when it will be impracticable to inspect them by the use of the rhinal mirror, or indeed, in any other way than the one here indicated.

By the employment of cocoaine, the vessels can be notably constricted. In this way the soft cushiony masses of tissue can be held

well out of the way (a very great advantage), at the same time, the cocoaine will exert its useful effect in obtunding sensibility. That the effect is to any extent that of a local anæsthetic, I have great reasons to doubt, but it is an exceedingly useful agent, and enables satisfactory treatments (often prolonged and tedious), to be borne by young children and nervous adults with the greatest possible satisfaction. It is curious that the cocoaine is ineffectual in some instances. I have now under my care a child six years of age, upon whom it has utterly failed. It produced no constriction of the vessels, and no diminution of sensibility. In other instances, I have remarked that the effect is exceedingly transient, lasting only for five, at the utmost ten minutes, and is practically of no use in controlling exaltations of sensibility. Dr. F. H. Bosworth, was the first to record the striking effects of cocoaine in constricting the blood vessels of the mucous membranes of the nose. It must, however, occur to any one who employs it, so decided are its effects in the majority of instances; but it is not a little curious that the first two patients upon whom I tried its effects were the two whose cases I have alluded to. The use of the cocoaine must not be forgotten in connection with the employment of high grades of heat in the electrode. I have never ventured to use it on a surface which was very vascular, without first freely using the cocoaine; for it is in every way probable that the scintillating white heat might cause free bleeding, no matter how little used, upon large uncontracted venous sinuses.

Since the weight of the handle of the electrode is considerable, it may under some circumstances be advisable to insert the electrodes (possibly one in either nasal chamber) and to touch lightly the free ends of the portions projecting beyond the nostrils with the handle of the electrode, at the time that the current is passed into the instrument by means of the interrupter. Of course, the moment the contact is made with the two poles of the electrode, there will be a flash of heat at the platinum loop which is lodged against the tissue desired to be cauterized. The advantage which is secured by applications made in this manner is conspicuous. In those patients who are unusually sensitive to pain or those who for any reason cannot properly control the motions of the head, such untoward disturbance cannot change the positions of the electrodes; for the backward and lateral motions of the head will simply break the contact between the electrode and the conductimg wires. With the instrument in which the electrode and wires are firmly united (see Fig. 2), the motion of the head will often rudely disturb

the position, cause cauterizations to be made in undesirable parts, and prove in every way to be annoying and unsurgical. In some instances, I have employed an electrode which retains a long, slender, flexible platinum loop, which can take any form desired by moderately exerted pressure, and which when thrust through the nose so as to touch the vault of the pharynx will conform to the curvature of that wall, and thus enable the operator to reach a point much further back than he possibly could by a straight, rigid instrument.

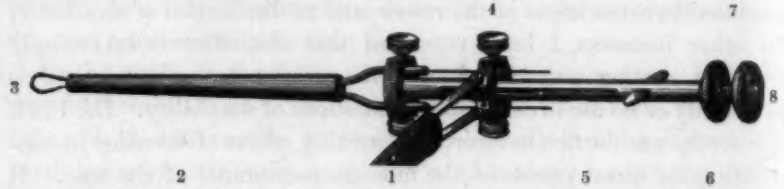

FIG. 3.—The galvano-cautery snare described in the text.—1. The cable of the battery; 2, the canula (which is not shown in full length); 3, the platinum wire; 4, the vulcanite carriage, with screws holding the ends of the platinum wire, with metallic contact with the hinge connections, by which the current is transmitted from the cables to the wire; 5, slotted barrel of aluminium; 6, a movable nut on the screw; 7, a small portion of the screw disengaged from the slotted barrel; 8, milled stationary screw-head.

A great advantage of the use of the galvano-cautery is its application to the principle of the snare. It is well known that a loop of wire which is steadily narrowed has great power in severing the attachment of tumors and other outgrowths. When of a large size they may be sufficiently powerful to pass through bony structures, as well as the softer parts of the body. The principle of the snare has been employed both in the throat, the ear, and the nose; but when my attention was first directed to this subject the forms available were too large and heavy for the delicacy of manipulation demanded in removing small tumors lodged in the narrower recesses of the nose. Moreover, no snare that I could then find would permit the galvanic current to pass through the loop at the time it was being narrowed. I was led, therefore, to inquire into the practicability of an instrument which would be at once light, of small size, and yet sufficiently powerful to remove that class of hypertrophied tissues and polypoid growths which are of such frequent occurrence in the nasal chambers. The instrument shown in Fig. 3 combines these qualifications, and satisfactorily performs the service for which it was designed. The only feature of an essential character which may be said to be novel is the fact that the platinum wire (3, Fig. 3) forming the snare is covered with a

uniform coat of copper, except alone the portion forming the loop, which is bare. As a consequence of this arrangement the current of electricity from the battery is conducted through a double canula (1, Fig. 3) by means of the copper.

The slotted barrel (5, Fig. 3) of the instrument, including the milled screw-head (8, Fig. 3) is of aluminium. The carriage (4, Fig. 3) is of vulcanite. The cables (1, Fig. 3) are attached to the carriage by a swinging pivot, the invention of Mr. Starr, of the S. S. White Manufacturing Company. The weight of the instrument is less than half ounce. The canula measures four inches in length; the aluminium shaft four inches. The length of the instrument is therefore exactly eight inches when the screw and carriage are carried well within the shank but when withdrawn to its utmost the length of the entire instrument is nine and a half inches. The advantages of the electrical snare over others in use are; the facility with which the small loop can be carried against a small growth not exceeding the size of a grain of wheat or corn; the ability to grasp readily the pedicle, and by a few turns of the movable nut to cut its way into the tumor, when by an application of the current, all points of resistance can be easily overcome. The most vascular structures may be freely entered and divided. If a growth be hard, resilient, or of a size so large as not to enable the loop to be readily engaged upon its base, the wire is simply held against the side of the growth, when the current will gradually burn its way into the mass to any extent which may be determined by the operator. When it is in this way received within the growth, the loop may, as before, be narrowed and a portion of it removed. It will be seen that failure to remove at least a portion of the growth attacked is an event exceedingly unlikely to occur. I have been particularly struck with the facility with which hypertrophies of the inferior turbinated bone can in this way be treated, and if cocaine be freely applied before the operation, it constitutes, in my judgment, the most speedy and the least painful of any means by which such conditions can be reduced. The current passing through the battery to the instrument can be interrupted by any of the numerous devises with which the practical electrician is familiar, or the treadle of the battery can be depressed and locked, and the interruption of the current be determined by the pressure of the finger on the key in the handle. This is under all circumstances desirable, since the weight of the cells is sufficient to demand considerable force to be exerted by the foot, always enough to destroy the delicacy of the manipulation of the instrument.

GLIMPSES OF THE INTERNATIONAL ELECTRICAL EXHIBITION.

By Professor Edwin J. Houston.

No. 7.—Drawbaugh's Telephonic Inventions.

A history of the articulating telephone would be incomplete without a description of the instruments, which Daniel Drawbaugh of Eberle's Mills, Pennsylvania, claims that he invented, constructed, and operated considerably prior to the earliest date of invention claimed by Alexander Graham Bell. Drawbaugh claims to carry back the date of his invention to some time between 1860 and 1861. He claims to have constructed his first instruments a few years afterwards, and brings witnesses whose credibility and integrity appear unquestioned, to corroborate his testimony. From these witnesses it appears to be established that at an early date he was working on instruments designed to transmit speech through conducting wires, by means of electrical currents, and that he actually did construct such instruments, and successfully employ them in connection with some of said witnesses in the transmission of articulate speech. That he was so experimenting appears to be a notorious fact in the neighborhood in which he lived, as more than one hundred witnesses taken from among his neighbors amply testify, some of them pointing out and recognizing the original apparatus used. The direct testimony of so many apparently unprejudiced witnesses, which does not appear to have been successfully controverted, would seem to establish, beyond a reasonable doubt, the claims of Mr. Drawbaugh as one of the prominent followers of Reis in his invention of the speaking telephone.

Drawbaugh's inventions came prominently before the public during the famous suit between the American Bell Telephone Company and the People's Telephone Company, the latter Company being a corporation operating under Mr. Drawbaugh's inventions. This suit, which was noted for the length of time it has been pending, and the voluminous testimony introduced by both sides, was only recently decided against Drawbaugh in the United States Circuit Court, in the Southern District of New York.

It is not our intention, except incidentally, to discuss here the relative claims of Drawbaugh and Bell as to priority of invention of the forms

of articulating telephones produced by them; nor to follow or discuss the decision of the court in the proceedings in equity in this case. Whether or not Drawbaugh can actually establish his claims in the court of last resort, we must leave to the final decision of such court. We desire rather to give merely such descriptions of the apparatus which Drawbaugh claims to have constructed, and in support of which claims he brings forward what appear to be reliable and trustworthy witnesses, as will acquaint our readers with the position he claims to occupy in the history of the invention of the telephone.

Whether or not Drawbaugh can explain his long delay in applying for letters patent by reason of straitened circumstances, or whether or not he can show due diligence in prosecuting his invention, and can thus establish the fact of non-abandonment of the invention we will not discuss; since neither of these questions can materially affect the operation of the apparatus we are about to describe.

The earliest date claimed by Mr. Drawbaugh for his first conception of transmitting speech by means of electricity was some time during his attendance at a course of lectures on Physics, delivered prior to 1860, near Milltown, by Prof. Heiges. The lecturer testifies that after the lectures Drawbaugh had frequent discussions with him on electrical subjects, and during these discussions expressed his belief as to the possibility of transmitting speech through wires by electrical currents. This would appear to fix the date of conception to some time prior to 1860. Drawbaugh, himself, however, testifies that his own recollection of the matter goes back to some time in 1861, during a visit to Washington, D. C., when he recalls a conversation with some parties respecting the electrical transmission of speech. The date of conception of the idea would, therefore, appear to be some time between 1860 and 1861.

The earliest form of transmitting instrument was made and used by Drawbaugh for the variation of an electric current by the human voice some time in 1866 or 1867. This instrument does not appear to have been preserved; Drawbaugh, however, testifying under oath, makes the sketch shown in Fig. 1, as fully describing the same

This apparatus, here shown, consisted of a cup *D*, of ordinary porcelain or earthenware, and therefore a non-conductor of electricity. Over the mouth of this cup, a diaphragm *B*, of flexible material was stretched and suitably secured to the rim. A metal rod *C*, was attached at its upper end to the middle of the diaphragm, and terminated at its lower

end, in a metal plate *E*. A metallic wire *G*, passed down one side of the cup and was connected with a second metallic plate *D*, that rested on the bottom of the cup. Between the two plates *E*, and *D*, a material was placed, which was styled by Drawbaugh a "low conductor of electricity," that is to say, a high resistance. This material, which is shown in the figure at *F*, was, it appears, the subject of very numerous and frequent experimentation by Drawbaugh, and was made of different substances at various times. Among the materials tried, he mentions fine, clean earth, used either alone or in combination with plumbago, or plumbago alone was employed, or finely pulverized charcoal. The cup apparatus was placed in the circuit of a voltaic battery and with some form of receiving instrument.

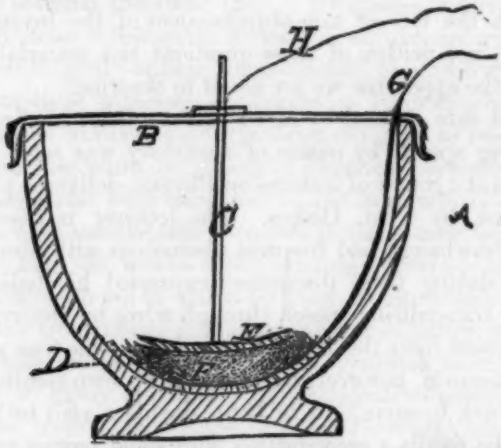

FIG. 1.—Sketch of Drawbaugh's Early Form of Transmitter.

The interest attached to this early form of instrument, assuming of course, that it was constructed as claimed, and placed in the circuit of a voltaic battery and receiving instrument, at a date as early as some time in 1866 or 1867, arises of course from the fact that it contained in it the essence of the invention claimed by Bell as being essential to the very existence of the articulating telephone; viz., the means whereby an electrical current could be set by the human voice, into undulations, as distinguished from the intermittent currents, which it has been claimed are necessarily transmitted by the old form of Reis transmitters. For, the instrument designed by Drawbaugh was intended to be used as follows; viz., the speaker, talking against the membrane *B*, caused it to be set into vibrations by means of the sound-waves impinging

thereon. The movements of the diaphragm, so produced, causing the plate *E*, to move towards and from the plate *D*, subjected the material *F*, to variations of pressure, and consequent variations of resistance, and thus threw on the circuit of the battery the so-called electrical undulations which have been assumed as necessary to the successful transmission of articulate speech.

The issue here raised between Bell and Drawbaugh, is, it will be seen a vital one. Since all that has been claimed for Bell, as of essential novelty in telephony is, we believe, practically, limited to the production of an undulatory current as distinguished from the so-called pulsatory or intermittent current of the Reis transmitter. If then, Drawbaugh can clearly establish the fact that at this early date, he constructed and operated such a form of transmitting instrument, he entirely removes Bell's claims as the inventor of such a device, in the broad manner which Bell endeavors to hold.

The early form of receiving instrument used in connection with the original cup-transmitter appears to have been of the form of a magnetic diaphragm receiver, somewhat similar to the form in which a non-magnetic diaphragm, such as bladder or other membraneous material, has connected with it a magnetizable material serving as the armature of an electro-magnet placed in the circuit of the transmitting instrument. Its form, and the arrangement of its details, as claimed by Drawbaugh, is shown in the sketch in Fig. 2.

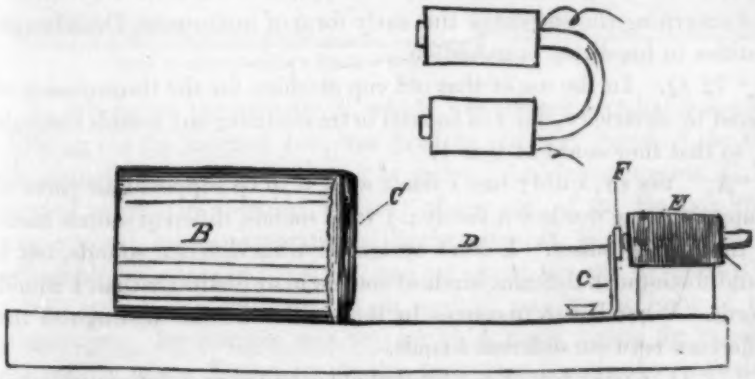

FIG. 2.—Sketch of Drawbaugh's Early Form of Receiving Instrument.

A tin can *B*, without top or bottom, was covered with an elastic diaphragm *C*, of membraneous material and mounted, in the position shown, on a suitable support. An electro-magnet *E*, had its armature

F, supported on a spring arm *G*, secured to the base in the position shown. A cord, or string *D*, attached to the centre of the diaphragm connected it with the armature *F*, of the electro-magnet. The tin can *B*, was coated on the inside with plaster of Paris, under the impression that the sound produced in the can by the movements of its diaphragm would thereby be improved.

This receiving apparatus was connected with the cup-transmitter and a voltaic battery, in the manner indicated in the sketch of Mr. Drawbaugh shown in Fig. 3.

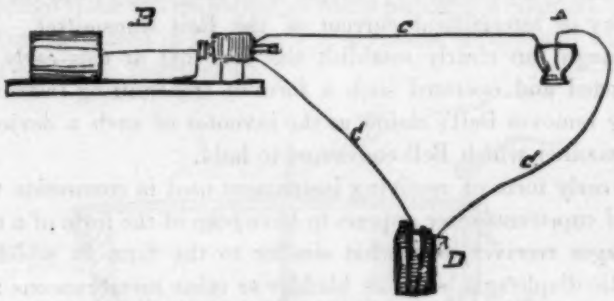

FIG. 3.—Sketch of Drawbaugh's Telephonic Circuit.

In this figure the receiving instrument is shown at *B*, and the cup-transmitter at *A*. These instruments were placed in the circuit of the voltaic cell *D*, by the circuit wires *C*, *C*, *C*, as shown.

Concerning the success of this early form of instrument, Drawbaugh testifies in his direct examination.

"72 Q. In the use of that old cup machine for the transmission of sound by electricity, did you succeed in transmitting any sounds through it, so that they could be heard?

"A. Yes sir, I did; but I don't want it to be supposed all parts of sentences, some words but feebly; I tried sounds, different sounds made in the way of noises. I don't remember what different sounds, but I could distinguish different kinds of sounds more distinctly than I would words. What I wish to convey by that is, that I could distinguish the difference between different sounds.

"73 Q. Could you or not by that old cup machine, distinguish vocal sounds from other kinds of sounds?

"A. Yes sir, I know that the results I had there, were sufficient to encourage me to go on with the experiments."

Drawbaugh claims that subsequent improvements in transmitting

instruments enabled him at an early date in his investigations to obtain from the same form of receiving instruments what he termed "true copies" of the sounds transmitted, and permitted him to hold conversation and transmit whole sentences intelligibly.

A slight modification of this form of receiving instrument, made as claimed by Drawbaugh some time afterwards, in 1867–1869, is shown in Fig. 4, in plan and elevation.

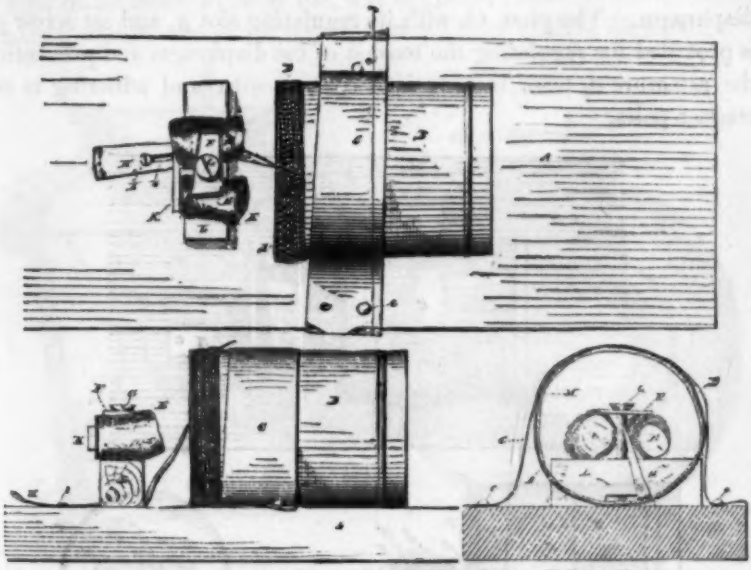

FIG. 4.—Drawbaugh's Early Form of Receiver. (Exhibit B.)

In this figure, the cylinder *B*, which was formed of what is apparently an old tin mustard box, was fixed to the base board *A*, by the tin strap *C*, fastened to the board by tacks. An electro-magnet *E*, *E*, formed as shown, mounted in front of the end of the tin box that was covered by a membraneous diaphragm. *H*, is a tension plate, adjustable by means of the slot *h*, and set screw *i*, its end terminated in a little strip that is supported in an upright position in front of the diaphragm. Its purpose was to provide a ready means for varying the tension of the diaphragm, as also to prevent the armature attached to the diaphragm from striking against and adhering to the poles of the electro-magnet.

Subsequent modifications were given to this receiver during repeated experiments made on it by Drawbaugh. It will be seen that in its

essential details it is the same as in the earlier form, as shown in Fig. 5.

In this drawing the hollow cylindrical receiver is shown at *B*, secured to the base board *A*, by means of the strap *C*. A diaphragm D^1, of animal membrane, is securely fixed to one end of *B*, by means of cord *H*, wrapped around the end in the manner shown. The electro-magnet *E*, is supported on a block so as to have its poles near, but not in contact with an armature *d*, fixed to the centre of the diaphragm. The plate *G*, with its regulating slot *g*, and set screw g^1, is provided for regulating the tension of the diaphragm and preventing the armature *d*, from coming into contact with and adhering to the magnet poles.

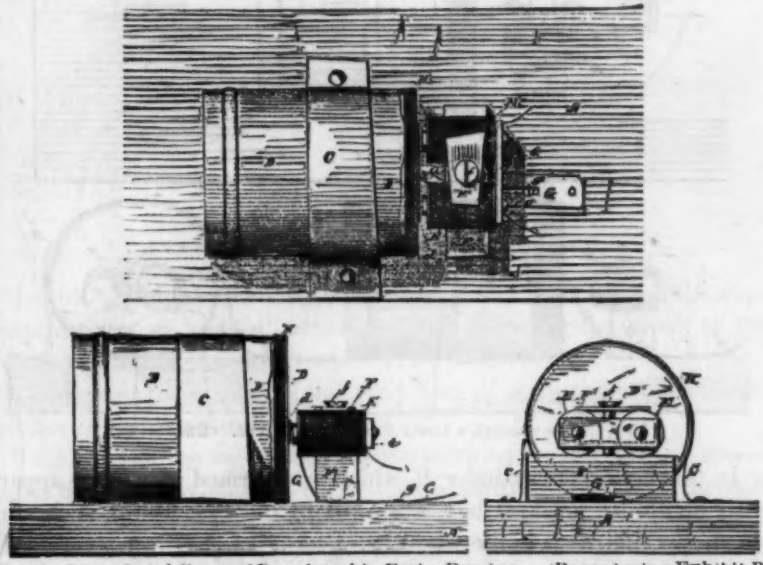

FIG. 5.—Reproduced Form of Drawbaugh's Early Receiver. (Reproducing Exhibit B.)

The next form of transmitting instrument is shown in Fig. 6.

The tumbler transmitter, as will be seen by an inspection of Fig. 6, was similar in the arrangement of its parts to the old cup transmitter. The pulverized low conductor, however, instead of being placed in the bottom of the tumbler was placed between two metallic plates suitably supported near the middle of the tumbler.

The disposition of parts were as follows: *A*, is a glass tumbler, lined with a thin layer of plaster of Paris, A^1. A wooden cup, *B*, serving the purpose of a mouth-piece, is securely attached to the top of the tum-

bler. This also is lined with plaster of Paris, B^1. A membranous diaphragm was attached to the top of the tumbler. The low conductor was placed between the two metal plates, D, and E; the adjustable rod, C, provided for the support of the lower plate, D, passed down the side of the tumbler. The wire, c, was intended for connection with the upper plate, an old soldered joint showing at d. The rod D, served for the electrical connection to the lower plate.

This transmitter, when in use, was of course placed in the circuit of a battery with the receiving instrument we have already described.

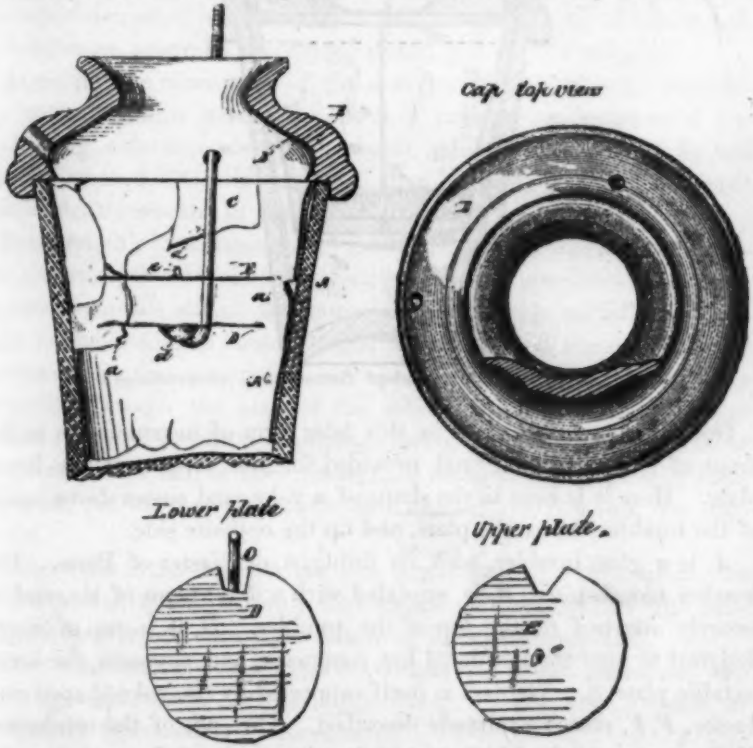

FIG. 6.—Drawbaugh's Tumbler Transmitter.

The tumbler as originally used was entire, and Drawbaugh testifies that, in order to improve the action of the powdered low conducting substances that he placed between the plates D, and E, he was in the habit of moistening them by placing a little water in the bottom of the tumbler. During the frequent experiments with this instrument the bottom of the tumbler broke off, as is represented in the drawing. He

still continued to employ the instrument, and thus found that the moisture of the conductor did not have the beneficial effect he had formerly ascribed to it.

The results of experimentation with this instrument finally produced the modification shown in Fig. 7, which, it is claimed, is a reproduction of the apparatus as Drawbaugh made it at this early date.

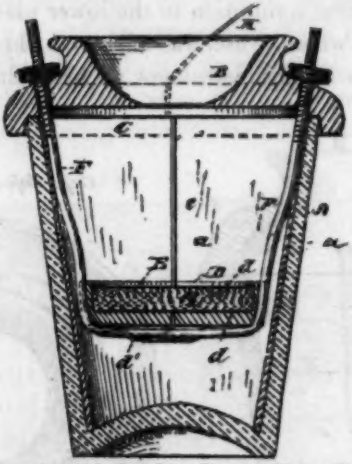

FIG. 7.—Drawbaugh's Tumbler Transmitter. (Reproduced.)

One difference observable in this later form of instrument is in the shape of the conducting rod provided for the support of the lower plate. Here it is bent in the shape of a yoke, and passes down inside of the tumbler, under the plate, and up the opposite side.

A, is a glass tumbler, with its lining, *a*, of plaster of Paris. The wooden mouth-piece, *B*, is provided with a diaphragm of tin, and is securely attached to the top of the tumbler. *D*, is a cup of wood, designed to hold the powdered low conductor, and supports the lower metallic plate, *d*. The box is itself supported by the yoke-shaped conductor, *F*, *F*, placed as already described. The ends of the conductor, *F*, *F*, are provided with set screws for the purpose of permitting the ready adjustment of the position of the box, and hence of the pressure on the conductor. The upper metallic plate rests on the surface of the conductor, and is rigidly connected with the diaphragm by the rod *e*, formed of conducting material. A marked alteration in the shape of the mouth-piece must also be noticed.

This later form of apparatus shows a great advance on the one seen

in Fig. 6. In the substitution of a metallic diaphragm for the membranous diaphragm of the former instrument a great step was taken by Drawbaugh in the improvement of the articulating telephone. Apart from the fact that membranous diaphragms are greatly affected as to their tension by the hygrometric state of the atmosphere, the mere moisture in the breath of the speaker was apt to introduce difierences in the tension of the diaphragm that were very apt to throw the low conducting powder out of the pressure best adapted for the most successful operation. Drawbaugh testifies that in the early stage of his experimentation he frequently employed diaphragms of thin metallic substances, generally employing tinned iron for the purpose.

Assuming the correctness of the statements of Drawbaugh concerning his experiments as to the effects of pressure on powders of low conducting substances, it would appear that at this early date he had already reached the point attained later by Edison, who afterwards independently worked in the same direction.

Drawbaugh's ideas concerning the nature of the action which pressure exerts on the electrical conducting power of powdered substances, appears from his direct testimony to be somewhat as follows, viz.: when in the state of a loose powder, the particles of the substance are separated by non-conducting air spaces, and conduct or pass the electricity through the mass of the solid substance at the points of contact only. The effect of pressure being to increase the number of the points in contact, or their breadth, or both, would necessarily have increased the amount of current that would pass through the conductor.

It appears, therefore, that the idea conceived by Drawbaugh at this early date was quite plausible, and shows that he reasoned with considerable power concerning the nature of his experimentation.

The comparatively small space between the mouth-piece and the diaphragm also marks a great improvement. Drawbaugh appears, in the various instruments he constructed, to have devoted considerable time to experimenting with mouth-pieces of vaious shapes. The shape of the mouth-piece shown in Fig. 7, is the one that is now generally employed in the art, as giving the best results in the transmission of articulate speech, and, indeed, in the receiving instrument itself, in the reproduction of the transmitted speech. Most of his first diaphragms were large and high, and necessarily contained a large amount of air. As early in his experiment, however, as the date of the later tumbler

transmitter, it would appear that he ascertained, as the result of repeated trials, the good effects of small, low mouth-piece.

The use of the wooden cup for the reception of the pulverized low conductor was not in itself much of an improvement. Its adoption by Drawbaugh was for the purpose of experimenting as to the effects of moisture on the action of the low conductor. He had tried the effects of actually wetting them by pouring water over them, and finding that this greatly interfered with their action, he devised the cup for the purpose of leaving a space below the low conductor in which he placed water, thus permitting it to slightly moisten the pulverized conductor by evaporation. We have already pointed out how the accidental breaking of the bottom of the tumbler enabled him to ascertain that the presence of moisture was not beneficial as previously believed.

The elimination of the error of moistening the pulverized low conductor appears to have enabled Drawbaugh to achieve greater success in his experiments with different forms of resistances. In replying to a question as to the nature of the substance used in the tumbler transmitter he testified, "I don't remember whether I used earth in the tumbler transmitters; in the former instrument, that is, in the cup, I used earth; in this or the tumbler instrument, I had used plumbago alone, and I had used plumbago mixed with other materials; that is with carbons, and pulverized charcoal and plumbago; and at times I had used charcoal alone; at other times finely divided coke and charcoal mixed, and also pulverized coke alone. I had used bronze, that is, finely divided metals, mixed with carbon or coke. I generally had bronze in the shop."

As to the successful use of the tumbler transmitter with the tin can receiver already described, the testimony of apparently credible witnesses show that they were repeatedly used for the transmission of intelligible, articulate speech. They were used on a telephonic circuit placed in Drawbaugh's shop, and run in various directions. These experiments extended over several years. The shop had a basement nearly underground. The next story above connected with the basement by a staircase. Another staircase communicated with room above. Doors placed in the upper rooms shut them off from each other and from the basement.

As to the manner of trial we will quote in the language of an answer by Drawbaugh in his sworn testimony.

"I sometimes would have the transmitter in the cellar; that would be three floors or stories below where the receiver would be; I mean the third story below. I also tried them in different rooms, having the transmitter in one room and the receiver in another, on the same floor; I also tried them with one floor between them, one in the part of the shop where we worked, and which we called the first story, and the other in the story next above that; oftentimes I would have one instrument on the second story at one end of the shop, while the other instrument would be on the first story at the opposite end of the shop. I am positive that the sounds received or produced came through the instruments."

The circuit wires were arranged in different ways, passing through the walls and ceilings, and fastened to the same. At times he increased the electrical distance between the transmitting stations by the introduction of a large coil or roll of wire into the circuit. He also experimented with ground and return circuits, and with metallic circuits.

The circuits thus established, it is claimed, were tested in various ways. He would place a clock or watch in the neighborhood of the transmitter and listen at the tin can receiver. Whenever he could press people into the service he would place them either at the transmitting end or at the receiving end. He would read some advertisement or other matter at the transmitter and then go to the party at the receiver and get him to repeat to him what was heard, or he himself would listen and repeat the message orally afterward to the party sending it.

Drawbaugh's first form of telephone did not therefore belong to the class of magneto-electro instruments in which the sound waves produce the currents necessary for the transmission of speech. It was an instrument that belonged to the class of transmitters in which the action of sound waves on the diaphragm of the transmitter varies the electrical resistance of a current that already exists.

CENTRAL HIGH SCHOOL,
PHILADELPHIA, March 12, 1885.

(To be continued.)

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS ON THE METZLER & BURRELL SIGNAL-LANTERN.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, *June*, 1884.

The Sub-committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred for examination

THE METZLER & BURRELL RAILWAY SIGNAL-LANTERN,

reports that, the invention is a signal-lantern for railways having two globes, one forming the upper half of the lantern body and the other the lower half. A single lamp, which is fixed immovably to the bail of the lantern, supplies light to either of the globes as may be desired, the body of the lantern being made to rotate upon a central axis around the lamp, so that one or the other of the globes may thus be illuminated in turn.

The globes are of different colors. They may be of any two colors which it may be found desirable to combine for use in signaling; but, in reality, red and white, and red and green are generally combined, these being the two combinations which are found most serviceable for use in signaling by trainmen and crossing-flagmen.

The object of the invention is to provide trainmen and crossing-flagmen with a lantern which they can use for giving their usual safety signal, and which they can instantly convert into a danger signal in case of necessity, by simply reversing the body of the lamp, thus turning the globes end-for-end.

The advantages of thus combining two signals in one lantern are two-fold:

First.—It enables the railway companies to dispense with one-half the number of lanterns they usually require, thus entailing a decided economy in the item of cost for lanterns, wick, cleansing, etc., and

Second.—It places a danger signal, at all times, at the instant service of the trainmen and crossing-flagmen, a circumstance which may frequently enable them to avert a serious accident.

The Committee is of opinion that the invention of Messrs. Metzler & Burrell is one of great utility and is worthy of the highest commendation which the Committee on Science and the Arts can bestow.

(Signed) LUTHER L. CHENEY,
RUFUS HILL,
WM. P. COX.

Adopted *Dec.* 3, 1884.

(Signed) H. R. HEYL,
Chairman.

[SEAL.]

I certify that the above is a true copy from the record.

(Signed) WILLIAM H. WAHL,
Secretary.

Book Notices.

THE MATERIALS OF ENGINEERING. PART III. NON-FERROUS METALS AND ALLOYS. By Robert H. Thurston, A.M., C.E. etc. New York: John Wiley & Sons, 1884. 8vo, pp. 575.

Part III of Professor R. H. Thurston's MATERIALS OF ENGINEERING is devoted to the consideration of such of the non-ferrous metals as are really available for the purposes of the engineer. These are chiefly copper, tin and zinc and their numerous alloys; but Prof. Thurston also describes at greater or less length all the metals used in construction, and completes the list by a brief enumeration of the rare, or precious metals, whose qualities do not in general fit them for use in construction and whose first cost renders their employment impracticable even when they have properties of a valuable kind.

Chapter I touches on the history of the use of metals as far as we are able to trace it, and also treats at some length on their physical peculiarities and the methods employed in reducing them from their ores. The "useful" metals are described as iron in its various forms, copper, lead, tin, zinc, antimony, bismuth, nickel, and occasionally aluminium and others of the rare metals. The special qualities of the so-called "useful" metals are defined as *strength*, *hardness*, *density*, *ductility*, *malleability*, *fusibility*, *lustre*, and *conductivity*, and in a series of tables the metals are compared as to the degrees in which they possess these various properties.

Chapter II describes the non-ferrous metals more at length, describes the various ores, the chief localities in which they are found, the treatment of the ores, the various uses of the different metals in the arts and their comparative cost. The properties of alloys in general, their chemical nature and physical qualities are treated in Chapter III, while the two succeeding chapters consider in turn the copper-tin alloys or bronzes and the copper-zinc alloys or brasses. The Kalchoids, alloys of copper, zinc and tin, and miscellaneous alloys of various metals, alluminium bronze, German silver, Babbitt metal, etc, are described in Chapter VI, while the manufacture and working of the various alloys used in the arts is discussed in Chapter VII.

The remainder of the book, with the exception of the last chapter, is devoted to the consideration of the strength of the non-ferrous metals and their alloys and the conditions which modify or affect their strength. A great deal of information has been collected from various sources, the results obtained by many observers are given, extracts made from investigations of the author and others for the United States Government Board.

Attention is again directed to the peculiar behavior of the various metals under continued stress or intermitted strain. It is noted that one class of metals, called by the author the "Iron Class," exhibits an elevation of the elastic limit, when subjected to a continued strain, while in the other, or "Tin Class," a corresponding depression occurs under the same circumstances. Thus the one actually becomes stronger under a continued strain, if that strain does not exceed the breaking strength, while the other will fail at

last under a load which it bore at first without yielding. From this fact it is obvious that the greatest care must be exercised to select a sufficiently large factor of safety, when we employ the metals of the "Tin Class," in constructions subjected to constant strain; and further that the breaking strength as determined in the ordinary way by rapid rupture cannot be relied upon as a measure of the strength after subjection to strain.

The fourteenth and concluding chapter bears the caption "Mechanical Treatment of the Metals," and describes some of the methods employed to increase the strength or remove the defects of the metals as found in the market. These methods of manipulation are chiefly such as change the volume, density and molecular condition, by causing flow while under stress. Among such processes may be mentioned cold-rolling, wire-drawing, forging under the drop, the hammer, or the hydraulic press, cold-hammering, annealing, etc. That which has probably attracted of late the greatest attention is Whitworth's process of producing solid steel castings, by subjecting the molten metal to a very heavy pressure under the hydraulic press, while the processes of contraction and solidification are being completed. A pressure of twenty tons to the square inch is said to produce all the compactness, density, strength and ductility of a steel forging, and the shrinkage under pressure amounts to an inch and a half for every foot of length. A similar process has been employed with excellent results by Colonel Lavroff in the manufacture of cast bronze guns. Methods have also been employed to increase the efficiency and durability of bronze ordinance by processes of cold working, such as enlarging the bore by forcing a succession of plungers of increasing size through it, and hardening the surface by a process similar to rolling.

In conclusion we would note that while a very large proportion of the matter of this volume has already appeared at various times in other publications, the compilations here presented will no doubt prove a valuable aid to the engineer, and an instructive text-book for the student. S.

Sulphurous Acid in the Atmosphere.—The general composition of the atmosphere is nearly constant, whatever may be the place or the height at which the air is taken. Sulphurous acid, however, is sometimes found in considerable quantities in the atmosphere of large industrial towns. From a long series of experiments at Lille, M. A. Ladureau, the director of the State Laboratory, found that the air contained 0·18 cubic centimetres of sulphuric acid per hectolitre, or 1·8 cubic centimetres per cubic metre. With a view of ascertaining whether this proportion was constant or variable according to the state of the atmosphere, he instituted special experiments and found that in calm weather the proportion rose to 2·2, while in strong winds it fell to 1·4 cubic centimetres. This fact is easily explained if we reflect that sulphurous acid gas, on account of its considerable density, tends to fall to the lowest portions of the regions where it is produced; it accumulates there upon days when the atmosphere is calm in greater proportion than when the wind has mingled the upper and lower layers of the atmosphere.—*La Nature*, March 29, 1884. C.

SPECIAL STAGE EFFECTS.—For an artificial moon M. Brandt uses a square frame containing eight Edison lamps. The anterior face of the frame is mounted with a translucent disk. The intensity of this artificial moon can be increased to 2,000 candles, which would be impossible in so small a space with gas, on account of the excessive heat. In order to produce apparitions, on a scene which is completely dark, small incandescent lamps are screened by an opaque covering, under the gauze which surrounds the character which is to appear. At the proper moment the light is opened upon the gauze so as to make an apparition of magical beauty. In like manner the sword, in Wagner's opera, *Walküre*, is illuminated suddenly by a small incandescent lamp, the light of which seems like a ray flashing from the sword. Contrivances have also been made for making stars shine on the heads of ballet dancers, whenever desired.—*Lumiere Electr.*, May 24, 1884. C.

COMPARISON OF COLORED RINGS.—When a copper plate is exposed to the flame of an alcohol lamp, a Bunsen burner, or an enameler's lamp, irridescent rings are produced around the heated point. Under favorable circumstances the colors become fixed, and apparently unalterable by the air. These thermal rings are like the electro-chemical rings of Nobili; like them, they follow one another and are propagated in waves. In both cases the colors are arranged in the same order as in Newton's rings when seen by transmission. Multiple thermal rings may be formed by means of metallic ajutages attached to drums, which are surmounted by two or more gas burners. The same apparatus may be used for the production of electro-chemical rings by placing steel needles of uniform length in the fine openings of the tubes. Decharme has sent a memoir to the French Academy, containing a comparative table and plates of the two kinds of rings, showing that the resemblance is maintained even in details. The resemblance becomes most striking when the jets of flame are small and slightly oxidizing.—*Comptes Rendus*, Sept. 1, 1884. C.

MAGNETIC PLATES.—When a thin plate of steel is placed in a uniform magnetic field, so that the lines of force are normal to the surface of the plate, there is formed a very flat magnet, of which the two faces are the two polar surfaces. The magnetic distribution, thus obtained, seems to disappear as soon as the plate is removed from the field. M. Duter employed tempered steel plates, with the thickness of a millimetre and diameters varying from 5 to 40 mm., with which he formed cylindrical piles. In some of these piles the plates were directly in contact, while in others they were separated by the use of paper or pasteboard. The piles were placed in the central portion of a very powerful magnetic field, and after they were withdrawn, they constituted regular permanent magnets, the sustaining force being greater in proportion as the plates were closer to one another. On dismounting the piles and carefully marking the upper and under surfaces of each plate, the magnetism was hardly perceptible; but when the pile was reformed, there was again a regular magnet, although weaker than at first. The separation of the magnet into its constituent elements and its reconstruction can be continued indefinitely.—*Comptes Rendus*, July 21, 1884. C.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, March* 18, 1885.]

HALL OF THE INSTITUTE, March 18, 1885.

WILLIAM P. TATHAM, President, in the chair.

Present—260 members and 105 visitors.

The minutes of the last meeting were read and approved.

The election of eleven new members was reported since the last meeting of the Board.

The paper for the evening was read by Mr. Frederick E. Ives, of Philadelphia, subject: "Isochromatic Photography," in which the author presented his claims to priority in the discovery and announcement of a practical procedure of producing photographic plates which are equally sensitive to every part of the visible spectrum, and by which he succeeded, as early as 1879, in producing pictures which brought out the full values of all those colors which photograph too dark by the ordinary methods.

Mr. Ives' paper has been referred to the Committee on Publication.

Prof. Edwin J. Houston, by request, gave a historical summary of the subject of autographic or fac-simile telegraphy, with especial reference to the recent advances in this direction accomplished by Mr. Patrick B. Delany, of New York. The speaker exhibited a number of specimens illustrating Mr. Delany's method of fac-simile transmission.

Prof. Houston's remarks have been referred for publication.

The Secretary's report embraced remarks on the efforts now being made by the U. S. Signal Officer to utilize the balloon as an aid in meteorological research; on the future of the glass industry in the United States; and on the progress made in the preparations for the forthcoming "Novelties" Exhibition to be held under the direction of the Institute in the autumn of the present year.

The following scientific and mechanical novelties were shown and described: on behalf of Jas. W. Queen & Co., of Philadelphia, laryngoscopes, otoscopes and ophthalmoscopes for surgical uses, supplied with minute Edison incandescent lamps; on behalf of J. C. Finn & Co., of Philadelphia, specimens of new materials for wall coverings, etc.; Wm. Walters' design for city subways; J. M. Williamson's improvement in vehicle wheels, and W. B. Eltonhead's improved nut-lock.

The Secretary exhibited a series of photographic views illustrating a number of the more noteworthy objects of interest in the World's Fair at New Orleans. These views were loaned for the purpose by Mr. Edward L. Wilson, of Philadelphia.

Mr. Thos. Shaw spoke, in very complimentary terms, of the services of Mr. D. S. HOLMAN, until lately Actuary of the Institute; and, in conclusion, moved that the thanks of the Institute be tendered to Mr. Holman. The motion was numerously seconded, and, on being put to vote, was unanimously adopted.

Adjourned.

WM. H. WAHL, *Secretary.*

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